Middle East Research Journal of Biological Sciences
ISSN 2789-7710 (Print & ISSN 2958-2091 (Online)
Frequency: Bi-Monthly
DOI: https://doi.org/10.36348/merjbs.2026.v06i03.001

Website: http://www.kspublisher.com/
Email: office@kspublisher.com

Parasitoid Communities Associated with Insects of Veterinary and Ecological Importance in Different Environments in Brazil

Carlos Henrique Marchiori[1]*, Klebert de Paula Malheiros[1]
[1]Institute Marco Santana, Goiânia, Goiás, Brazil

Abstract: This study synthesizes experimental investigations conducted under field and laboratory conditions to evaluate the diversity, distribution, and ecological importance of parasitoids associated with Diptera of veterinary, medical, and ecological relevance in Brazil. Data were compiled from multiple studies performed in different environments, including forest, rural, urban, and agricultural habitats, using standardized sampling procedures such as baited traps, exposure of organic substrates, pitfall traps, and pupal recovery for parasitoid emergence. The compiled studies revealed a broad diversity of parasitoid taxa, especially within the families Pteromalidae, Figitidae, Braconidae, Chalcididae, and Encyrtidae, associated with dipteran hosts developing in feces, carcasses, animal tissues, fruits, and other decomposing organic substrates. The most frequently recorded parasitoids included *Pachycrepoideus vindemmiae* Rondani, 1875 (Hymenoptera: Pteromalidae), *Nasonia vitripennis* (Walker,1836) (Hymenoptera: Pteromalidae), and species of the genus *Spalangia* Latreille, 1805, and other parasitoids of ecological and sanitary importance. Parasitism rates varied widely among hosts, substrates, and environments, indicating that host availability, substrate type, and environmental conditions strongly influence parasitoid occurrence and efficiency. In general, substrates rich in organic matter supported higher parasitoid activity, while differences among forest, rural, and urban habitats reflected variation in host density and habitat characteristics. These results highlight the ecological importance of parasitoids as natural regulators of dipteran populations and reinforce their potential use in biological control programs. The synthesis expands knowledge of host–parasitoid relationships in Brazil and supports the development of sustainable management strategies for insects of veterinary, medical, and agricultural importance.

Keywords: Biological Control, Environmental Diversity, Host–Parasitoid Interaction, Parasitoids, Population Regulation.

RESEARCH PAPER

***Corresponding Author:**
Carlos Henrique Marchiori
Institute Marco Santana, Goiânia, Goiás, Brazil

How to cite this paper:
Carlos Henrique Marchiori & Klebert de Paula Malheiros (2026). Parasitoid Communities Associated with Insects of Veterinary and Ecological Importance in Different Environments in Brazil. *Middle East Res J Biological Sci, 6*(3): 66-100.

Article History:
| Submit: 26.03.2026 |
| Accepted: 24.04.2026 |
| Published: 07.05.2026 |

1.0 INTRODUCTION

Parasitoids are important natural enemies of Diptera and play a key role in the regulation of populations associated with decomposing organic substrates. These insects, mainly belonging to the order Hymenoptera, develop by parasitizing immature stages of their hosts, especially larvae and pupae, contributing significantly to ecological balance and natural biological control (Marchiori *et al.,* 2004a; Marchiori, 2019a; Marchiori, 2019b; Gudin *et al.*, 2026; Huang *et al.,* 2026). Dipteran species such as *Musca domestica* L., 1758 (Diptera: Muscidae), *Chrysomya albiceps* (Wiedemann, 1819) (Diptera: Calliphoridae), and *Peckia chrysostoma* (Wiedemann, 1830) (Diptera: Sarcophagidae) are commonly found in substrates such as feces, carcasses, and animal remains. These flies have great medical, veterinary, and sanitary importance, as they are frequently associated with the transmission of pathogens to humans and animals (Marchiori, 2001; Marchiori *et al.*, 2004b; Marchiori, 2021a; Marchiori, 2021b; Guimarães *et al.*, 2026; Österman *et al.,* 2026).

Parasitoids such as *Pachycrepoideus vindemmiae* (Rondani, 1875) (Hymenoptera: Pteromalidae), *Nasonia vitripennis* (Walker, 1836) (Hymenoptera: Pteromalidae), and species of the genus *Spalangia* Latreille, 1805 are widely distributed and frequently recorded in association with synanthropic Diptera. These species exhibit diverse biological strategies, including solitary and gregarious development, and can parasitize a wide range of hosts across diverse environments (Marchiori, 2022; Schuster and Sivakumar, 2024; Teng *et al.,* 2026; Zhang *et al.,* 2026). Several factors, including substrate type, host availability, and environmental conditions such as temperature and humidity, influence parasitoid occurrence and efficiency. Organic substrates provide favorable conditions for Diptera development, which in turn support the establishment and persistence of parasitoid populations. Thus, understanding interactions among parasitoids, their hosts, and different substrates is essential for clarifying ecological relationships and supporting the development of sustainable biological control strategies (Marchiori *et al.,* 2004a; Marchiori *et al.,* 2004b; Marchiori, 2021a; Marchiori, 2021b; Hopper and Leung, 2026; Keith and Hopper, 2026).

The objective of this study was to analyze the relationships between parasitoids and their Diptera hosts across different substrates. Specifically, this study is aimed at: 1. Identifying the main parasitoid species associated with Diptera. 2. Evaluate the occurrence and distribution of parasitoids in different substrates. 3. Analyze parasitism rates in relation to host species. 4. Compare parasitoid–host interactions across environments. 5. Assess the role of parasitoids in the natural control of Diptera populations.

2.0. MATERIALS AND METHODS

2.1 General Approach

This study is a synthesis of experimental research conducted under field and laboratory conditions, focusing on parasitoid–Diptera interactions in different environments in Brazil (Goiás, Minas Gerais, and other regions). Data were compiled from multiple studies using standardized methods such as baited traps, organic substrates, and pitfall systems. All studies followed similar procedures: exposure of substrates, recovery of pupae, laboratory rearing, and identification of dipterans and parasitoids. Only studies conducted under field or semi-field conditions, involving decomposing substrates and reporting parasitoid emergence with quantitative data, were included. The compiled database included information on host and parasitoid species, substrate type, environment, number of pupae, and parasitoids emerged. Analyses evaluated parasitoid diversity, host–parasitoid relationships, and variation in parasitism rates across environments and substrates. Faunistic indices (constancy and dominance) were used to classify species. Although variations among studies may influence results, the use of standardized criteria allowed consistent comparisons.

2.2. Experimental Methods

1. Method 1

Matte, black-painted metal cans each had two louver-type openings located in the lower third to allow insect entry. Nylon funnels, open at both ends, were attached to the top of the cans with their bases facing downward and connected to plastic bags, which were removed for fly collection. Baits used to attract flies included bovine kidneys, human feces, chicken viscera, fish, fruits, and bovine liver, all placed inside the cans over a layer of soil. Five traps were suspended from eucalyptus trees at a height of 1 m above ground level, spaced 2 m apart and located 50 m from domestic waste. Collected specimens were transported to the laboratory, killed using ether, and preserved in 70% ethanol for subsequent identification. For parasitoid recovery, trap contents were transferred to plastic containers containing a layer of soil as a substrate for larval pupation. After 15 days, the sand was sieved to extract pupae, which were individually placed in size 00 gelatin capsules until the emergence of flies and/or parasitoids.

2. Method 2

Collected fruits, orange, star fruit, guava, mango, and pitanga were placed individually over a 5 cm layer of sterilized fine sand in transparent cylindrical plastic containers 600 mL, open at the top to allow aeration. The fruits were previously inspected to ensure the presence of infestation symptoms, such as oviposition marks or larval galleries. The containers were maintained under laboratory conditions, approximately 25 ± 2°C, 70 % RH, and natural photo period to allow larval development and subsequent pupation. As larvae exited the fruits, they burrowed into the sand layer to pupate. The substrate was examined weekly, and puparia were separated from the sand using the flotation method with water. Recovered puparia were carefully removed, counted, and transferred to glass vials containing a thin layer of sterilized fine sand to maintain humidity. Each pupa was kept under controlled conditions until the emergence of adult dipterans and/or parasitoids. Emerging insects were collected daily, identified to the lowest possible taxonomic level, and preserved in 70% ethanol for further analysis.

3. Method 3

Pitfall traps consisted of plastic containers measuring 15 cm in diameter and 10 cm in height. Each container was filled with 1 L of water, 20 mL of detergent, and 2 mL of formaldehyde, and buried so that its opening remained at ground level. A 150 mL cup was used to hold the bait and was suspended and centered within the trap using a thin wire attached to its rim. The trap was protected from excessive sunlight and rain using a cardboard cover supported by a wire at a height of 10 cm above the ground. Five traps baited with human feces were used and inspected every two weeks. The contents were analyzed for the presence of dipteran pupae and/or parasitoids. Pupae were individually placed in gelatin capsules until emergence. The parasitism rate was calculated based on the number of pupae obtained.

4. Method 4

Ten fresh fecal pats of cattle, buffalo, and chickens were marked immediately after deposition using white wooden stakes 30 cm in height and 5 cm in thickness to determine the time between deposition and collection accurately. Samples remained in the field for 15 days. Samples were then collected and transported to the laboratory, where pupae were extracted using the flotation method. Additionally, 5 cm of the underlying substrate beneath each fecal pat was collected. Pupae were separated using a sieve, counted, and individually placed in size 00 gelatin capsules until the emergence of dipterans and/or parasitoids. Emerging dipterans were identified using a stereomicroscope and preserved in 70% ethanol.

5. Data Analysis

5.1. Parasitism Rate was Calculated as: Number of parasitized pupae of each parasitoid species / total number of pupae of the host × 100.

5.2. Parasitoid host preference was evaluated using Chi-square (χ^2) ($P<0.05$) and analysis of variance (ANOVA) ($P<0.0001$).

5.3. The Constancy of Species Was Determined by the Formula: $C = (P \times 100) / N$. P = number of collections containing the species (total monthly samples), and N = total number of collections performed.

According to the percentages obtained, the species were separated into the following categories: constant species (X) - present in more than 50% of the collections; accessory species (Y) - present in 25% to 50% of the collections, and accidental species (Z) - present in less than 25% of the collections.

5.4. Dominance Formula

Upper Limit (UL): $UL = [n1 \cdot F0 / (n2 + n1 \cdot F0)] \times 100$ - Where: $n1 = 2(K + 1)$ - $n2 = 2(N - K + 1$.

Lower Limit (LL): $LL = [(1 - n1 \cdot F0) / (n2 + n1 \cdot F0)] \times 100$ - Where: $n1 = 2(N - K + 1)$ - $n2 = 2(K + 1)$.

Definitions: N = total number of individuals captured - K = number of individuals of a given species - F0 = value from the F distribution (5% probability level). Dominance Criterion: A species is considered dominant when LL > UL (for K = 0).

$D = Nmax/N$, where N is the total number of individuals and Nmax is the number of individuals of the most abundant species.

3.0. RESULTS

A total of studies analyzing parasitoids associated with Diptera in different substrates, such as bovine feces, human feces, carcasses, liver, fish, and others, were compiled. Across all studies, parasitoids belonging mainly to the families Pteromalidae, Braconidae, Chalcididae, Figitidae, and Encyrtidae were recorded. Some species occurred in multiple substrates and host species, indicating a wide ecological distribution and adaptability. Parasitism rates varied considerably among studies, ranging from 0.1% to 97%, depending on the host species, substrate, and environmental conditions. Lower parasitism rates were observed in more complex or less favorable environments, such as carcasses exposed under variable environmental conditions.

The results also showed several parasitoid species exhibited generalist behavior, parasitizing multiple Diptera species across different substrates. The compiled data from all studies revealed a wide diversity of parasitoid species associated with Diptera in different substrates and environments. As shown in Table 1, the most frequently recorded parasitoids were *P. vindemmiae*, *N. vitripennis*, and species of the genus *Spalangia*. These parasitoids were observed in several studies, indicating a broad ecological distribution and adaptability. *Brachymeria podagrica* (Fabricius, 1787) (Hymenoptera: Chalcididae) and *Aphaereta* sp. also showed considerable occurrence, particularly in substrates with high organic matter availability (Table 1).

Table 1: This table summarizes the principal parasitoid species identified across the analyzed studies, emphasizing those with the highest frequency of occurrence and ecological importance. These species are widely distributed and are commonly associated with Diptera developing in decomposing organic substrates

Parasitoid species	Occurrence	Ecological behaviour
Aganaspis pelleranoi	Low	Endoparasitoid
Aphaereta sp.	Medium	Gregarious
Brachymeria podagrica	Medium	Generalist
Doryctobracon areolatus	Medium	Larval endoparasitoid
Hemencyrtus herbertii	Low	Gregarious
Gnathopleura quadridentata	Low	Generalist
Nasonia vitripennis	High	Gregarious
Pachycrepoideus vindemmiae	High	Generalist
Spalangia cameroni	Medium	Pupal parasitoid
Spalangia drosophilae	High	Gregarious
Spalangia endius	Medium	Pupal parasitoid
Spalangia nigroaenea	Low	Pupal parasitoid
Spalangia spp.	High	Pupal parasitoid
Tachinobia sp.	Low	Gregarious
Trichopria sp.	Medium	Endoparasitoid

Regarding host species, the most parasitized Diptera were *M. domestica*, *C. albiceps*, and *P. chrysostoma*. These species are widely distributed and commonly associated with decomposing organic matter, which may explain their high frequency. Other hosts, such as *Sarcodexia lambens* (Wiedemann, 1830) (Diptera: Muscidae) and *Oxysarcodexia thornax* (Walker, 1849) (Diptera: Sarcophagidae), also showed relevant levels of parasitism (Table 2).

Table 2: These species are commonly associated with synanthropic environments and organic substrates such as feces, carcasses, and animal remain

Parasitoid species	Occurrence	Ecological behaviour
Aganaspis pelleranoi	Low	Endoparasitoid
Aphaereta sp.	Medium	Gregarious
Brachymeria podagrica	Medium	Generalist
Doryctobracon areolatus	Medium	Larval endoparasitoid
Hemencyrtus herbertii	Low	Gregarious
Gnathopleura quadridentata	Low	Generalist
Nasonia vitripennis	High	Gregarious
Pachycrepoideus vindemmiae	Highb	Generalist
Spalangia cameroni	Medium	Pupal parasitoid
Spalangia drosophilae	High	Gregarious
Spalangia endius	Medium	Pupal parasitoid
Spalangia nigroaenea	Low	Pupal parasitoid
Spalangia spp.	High	Pupal parasitoid
Tachinobia sp.	Low	Gregarious
Trichopria sp.	Medium	Endoparasitoid

The analysis of the substrate showed that parasitism rates varied by organic material type. Higher parasitism was observed in substrates such as feces and organic waste, reaching values of up to 97%, especially in the presence of gregarious parasitoids. In contrast, lower parasitism rates were recorded in substrates such as fish and carcasses, where environmental conditions may limit parasitoid activity. Overall, the results indicate that parasitoid diversity and parasitism rates are strongly influenced by host availability, substrate type, and environmental conditions (Table 3).

Table 3: The data highlight the influence of substrate type on parasitoid activity, demonstrating that environments rich in organic matter tend to support higher parasitism levels due to increased host availability and favorable developmental conditions

Substrate	Parasitism range (%)	Conservation
Bovine feces	0.4 – 11.2	High diversity
Bovine kidney	up to 97	High host density
Bovine liver	0.3 – 1.6	Moderate
Buffalo feces	0.1 – 1.3	Lower parasitism
Carcass	~0.4	Environment dependent
Chicken Maure	0.3 – 0.57	Controlled environments
Fish	0.3 – 0.4	Low
Forest environment	Variable	High humidity influence
Fruit (guava/pitanga)	0.14 – 16.2	Agricultural importance
Human feces	up to 4.9	High activity
Organic waste	up to 97	Very high (gregarious species)
Pasture environment	Variable	Lower diversity
Pig carcass	0.3 – 2.3	Forensic relevance
Slaughterhouse waste	0.1 – 15.3	High host availability
Urban organic waste	Variable	Synanthropic influence

4. EXPERIMENTAL STUDIES CONDUCTED

1. Species of *Spalangia* as Parasitoids of Muscoid Dipterous Insects in Cattle Feces in Goiás / 1.1. Method used (4)

A total of 475 specimens of the genus *Spalangia* were collected from 12,442 Diptera pupae, resulting in a parasitism rate of 3.8%. The most abundant host was *Sarcophagula occidua* Fabricius, 1794 (Diptera: Sarcophagidae), representing 32.8% of the collected individuals (Table 4).

Table 4: This table presents the occurrence of parasitoid species and their associated dipteran hosts in bovine feces. It highlights parasitism rates, host–parasitoid relationships, and species distribution in the studied environment

Parasitoid	Frequency	Host	Number of pupae	% Parasitism
Spalangia cameroni	22	*Brontaea debilis*	910	2.4
	36	*Brontaea quadristigma*	1006	3.6
	1	*Cyrtoneurina pararescita*	2650	0
	4	*Palaeosepsis* sp.	3759	0.1
	17	*Sarcophagula occidua*	4080	0.4
Total	**80**			
Spalangia drosophilae	157	*Brontaea quadristigma*	1006	15.6
	35	*Palaeosepsis* sp.	3759	0.9
	1	*Sarcophagula occidua*	4080	0
	1	Sphaeroceridae sp.	37	2.7
Total	**194**			
Spalangia endius	13	*Brontaea debilis*	910	0.7
	6	*Brontaea quadristigma*	1006	1.3
	2	*Cyrtoneurina pararescita*	2650	0.1
	4	*Palaeosepsis* sp.	3759	0.1
	6	*Sarcophagula occidua*	4080	0.1
Total	**31**			
Spalangia nigra	1	*Sarcophagula occidua*	4080	0
Spalangia nigroaenea	67	*Brontaea debilis*	910	6.4
	58	*Brontaea quadristigma*	1006	6.7
	17	*Cyrtoneurina pararescita*	2650	0.6
	3	*Palaeosepsis* sp.	3759	0.1
	24	*Sarcophagula occidua*	4080	0.6
Total	**169**		**-**	**-**

Among the parasitoid species, *Spalangia drosophilae* Ashmead, 1885 (Hymenoptera: Pteromalidae) was the most abundant, accounting for 40.9% of the total, whereas *Spalangia nigra* Latreille, 1805 (Hymenoptera: Pteromalidae) was the least frequent species, with only 0.2%. The highest parasitism rate was observed for *S. drosophilae* in pupae of *Brontaea quadristigma* (Thomson, 1869) (Diptera: Muscidae), while the lowest was recorded for *S. nigra* in pupae of *S. occidua* (Figure 1).

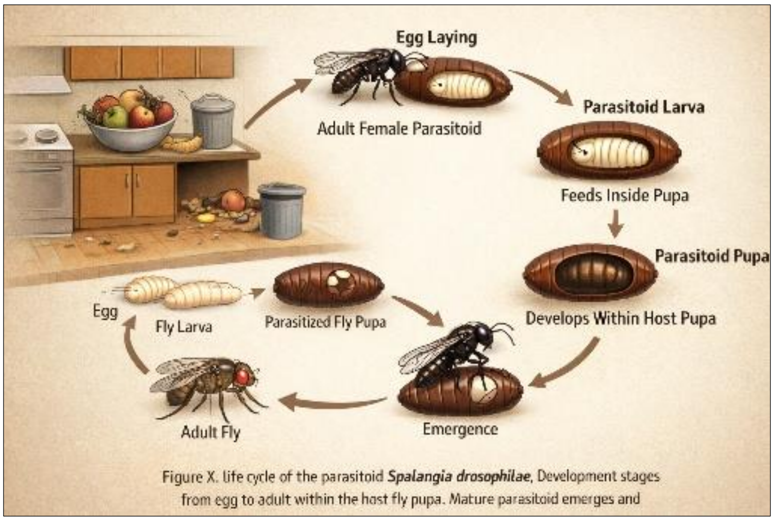

Figure 1: Life cycle of the parasitoid *Spalangia drosophilae*. Development occurs inside the host pupa from egg to adult stage. The adult parasitoid emerges from the parasitized puparium

Chi-square analysis indicated host preference patterns among species. *Spalangia cameroni* Perkins,1910 (Hymenoptera: Pteromalidae) showed a preference for *B. quadristigma*, *Brontaea debilis* (Thomson, 1896) (Diptera: Muscidae), and *S. occidua*. *Spalangia drosophilae* preferred *B. quadristigma*, *S. occidua*, and *Palaeosepsis* sp. (Diptera: Sepsidae), *Spalangia endius* Walker, 1839

(Hymenoptera: Pteromalidae) showed a preference for *B. quadristigma* and *S. occidua*, whereas *Spalangia nigroaenea* Curtis, 1839 (Hymenoptera: Pteromalidae) was associated with *B. quadristigma*, *B. debilis*, *Cyrtoneurina pararescita* Couri, 1995 (Diptera: Muscidae), and *S. occidua* ($\chi^2 = 36.0$; df = 12; P< 0.05).

These results suggest that *Spalangia* species can be considered the main parasitoids of flies associated with cattle dung in southern Goiás. This study also represents the first record of *S. drosophilae* parasitizing pupae of Sphaeroceridae. The species of *Spalangia* were strongly associated in terms of population density, indicating a stable coexistence relationship among them. Considering the population levels of *Spalangia* spp. collected in the field, it is likely that these parasitoids may be sufficient to control future infestations of *Haematobia irritans* L., 1758 (Diptera: Muscidae) or other pest species in rural environments (Marchiori *et al.*, 2001).

2. Occurrence of Fruit Flies and Their Parasitoids, Itumbiara, Goiás / 2.1. Method used (2)

The results showed a low diversity of frugivorous Diptera, with *Anastrepha fraterculus* (Wiedemann, 1830) (Diptera: Tephritidae) identified as the most important pest of fruit crops in the region of Itumbiara, Goiás. Among the parasitoids, *Doryctobracon areolas* (Szepligeti, 1911) (Hymenoptera: Braconidae) was considered the most important species associated with fruit flies in this region. *Neosilba* sp. (Lonchaeidae), number of individuals collected 136, species of parasitoid *D. areolatus*, number of parasitoids collected 2, and parasitism rate 1.5 (Table 5).

Table 5: It highlights parasitism rates, host associations, and species distribution in fruit substrates. The data also emphasize the importance of these parasitoids in the biological control of fruit fly populations

Taxonomic Group	Minas Gerais (MG)	Percentage	Goiás (GO)	Percentage
Aganaspis pelleranoi	0	0	3	6
Doryctobracon areolatus	6	13	43	90
Lopheucoila boulardi	10	22	0	0
Odontosema anastrephae	2	4.4	0	0
Pachycrepoideus vindemmiae	2	4.4	2	4
Spalangia endius	5	11	0	0
Trichopria anastrephae	20	44.2	0	0
Total	**45**	**100**	**48**	**100**

Anastrepha fraterculus was the only species recorded in all sampled hosts, demonstrating its wide distribution and ecological adaptability. Chi-square analysis indicated that *A. fraterculus* showed a preference for pitanga and guava, as well as for *Ceratitis capitata* (Wiedemann, 1824) (Diptera: Tephritidae) ($\chi^2 = 27.39$; df = 1; P< 0.05). In addition, *Neosilba* sp. was more frequent in pitanga, representing 66.6% of the individuals (Figure 2).

Figure 2: Male of *Trichopria anastrephae*. Adults have a lateral view showing sexuality. dimorphism. Details of antenna highlighting morphological differences between sexes. Source: Federico Triñnanes

Pitanga was the fruit that exhibited the highest parasitoid frequency, with 37 individuals, predominantly *D. areolatus*. *A. fraterculus* showed the greatest parasitoid diversity and the highest parasitism rate (16.2%). The parasitism rates for *D. areolatus*, *Aganaspis pelleranoi* (Brèthes, 1924) (Hymenoptera: Figitidae), and *P. vindemmiae* were 3.0%, 0.2%, and 0.1%, respectively (Table 6).

Table 6: It highlights variations in parasitism levels among species and their distribution in different fruit hosts. The data also emphasize the role of these parasitoids in the natural regulation of fruit fly populations

Taxonomic Group	Parasitism (%) MG	Parasitism (%) GO
Aganaspis pelleranoi	0	0.3
Doryctobracon areolatus	1.6	5.0
Lopheucoila boulardi	3.3	0
Odontosema anastrephae	0.7	0
Pachycrepoideus vindemmiae	0.7	0.5
Spalangia endius	2.0	0.2
Trichopria anastrephae	6.6	0
Total	**14.8**	**5.5**

No pupae of frugivorous flies were collected from oranges, which may be related to the short exposure time of the fruits in the environment or their low susceptibility. Chi-square analysis also showed that *D. areolatus* preferred larvae collected from guava fruits ($\chi^2 = 15.7$; df = 1; P<0.05). These results highlight the importance of parasitoids in regulating populations of frugivorous flies and reinforce their potential for use in biological control programs (Marchiori *et al.*, 2004a).

3. *Trichopria* sp. Parasitoids of Diptera / 3.1. Method Used (4)

The Diptera species parasitized by *Trichopria* sp. were similar in both sampling locations. In site 1 (Uberlandia, MG), the highest parasitism rate was observed in pupae of *S. occidua* (3.4%), whereas in site 2 (Itumbiara, GO), the highest value also occurred in pupae of *S. occidua* (3.4%). The total parasitism rate was 1.3% in site 1 and 1.5% in site 2, indicating a low level of parasitism in both environments. However, statistically significant differences were observed regarding the host preference of *Trichopria* sp. At site 1, *Trichopria* sp. showed a preference for *S. occidua* pupae (F=5.04; P<0.001), and at site 2, for both *S. occidua* and Sphaeroceridae pupae (χ^2=29.63; df=16; P=26.30). Diapriidae are primarily gregarious endoparasitoids of Diptera pupae, but in our study, *Trichopria* sp. proved to be a solitary parasitoid (Table 7).

Table 7: This table presents the dipteran host species associated with *Trichopria* sp. and their parasitism rates. It highlights host–parasitoid relationships, variations in parasitism levels, and species distribution

Parasitoid	Hosts	Frequency	Several Pupae	Parasitism %
Site1: Uberlândia, MG	*Brontaea quadristigma*	02	720	0.3
	Palaeosepsis sp.	40	4289	0.9
	Sarcophagula occidua	36	1060	3.4
	Sphaeroceridae	01	397	0.3
Total		79	6466	1.2
Site 2: Itumbiara, GO	*Brontaea quadristigma*	02	204	1.0
	Palaeosepsis sp.	40	4289	0.9
	Sarcophagula occidua	36	1060	3.4
	Sphaeroceridae sp.	01	397	0.3
Total		**79**	**5950**	**1.3**

In site 1, *Trichopria* sp. showed a preference for pupae of *S. occidua* (F = 5.04; P< 0.001), whereas in site 2, it preferred pupae of *S. occidua* and Sphaeroceridae ($\chi^2 = 29.63$; df = 16; P < 0.05) (Figure 3).

Figure 3: *Trichopria* sp are parasitoids of Calliphoridae, Muscidae, Sarcophagidae, and Tachinidae. Source: FlicKer

These results indicate that host selection by *Trichopria* sp. varies according to environmental conditions and host availability. Despite the low parasitism rates, the species demonstrates selective behavior, suggesting ecological adaptation to specific hosts in different habitats (Marchiori *et al.*, 2000a).

4. *Pachycrepoideus Vindemmiae,* a Parasitoid of Diptera in Brazil / 4.4. Method Used (1)

A total of 151 specimens of *P. vindemmiae* were collected from 2,447 Diptera pupae, resulting in an overall parasitism rate of approximately 6.2%. A high number of individuals was obtained from the host *C. albiceps*, representing 66.6% of the parasitoids collected. This species is of great medical and sanitary importance, as it is associated with secondary myiasis and the transmission of pathogenic microorganisms (Table 8).

Table 8: This table presents the dipteran host species associated with *Pachycrepoideus vindemmiae* across different substrates. It highlights host frequency, parasitism rates, and distribution in the studied environment

Substrates	Substrate Frequency	Species/Hosts	Frequency	Percentage
Cattle kidneys	45	*Chrysomya albiceps*	30	19.3
Cattle liver	53	*Peckia chrysostoma*	01	0.7
	1.7	*Fannia pusio*	02	1.3
Fish	40	*Oxysarcodexia thornax*	16	10.6
	37	*Sarcodexia* sp.	04	2.6
Human feces	123	*Fannia pusio*	07	4.6
	52	*Oxysarcodexia thornax*	08	5.3
	12	*Sarcodexia* sp.	04	2.6
	165	*Sarcophagula* sp.	39	25.8
	220	*Poecilosomella* sp.	40	26.5
Total	**2.447**		**151**	**100%**

Regarding the substrates, human feces showed the highest host diversity, with five parasitized species, and accounted for 64.9% of the collected parasitoids, 98 individuals. The highest parasitism was observed in *C. albiceps* collected from bovine liver (Figure 4).

Figure 4: *Pachycrepoideus vindemmiae* across different substrates. It highlights host frequency, parasitism rates, and distribution in the studied environment. Source: Photo de http://tribes.eresmas.net

The results indicate that *P. vindemmiae* is widely distributed among different substrates and hosts, demonstrating its ecological versatility. The presence of this parasitoid in various environments contributes to its maintenance in nature and enhances its potential as a biological control agent. The population levels observed under field conditions are likely sufficient to contribute to the control of pest insects, especially synanthropic flies (Marchiori *et al.*, 2003a).

5. *Nasonia Vitripennis, a* Parasitoid of Muscoid Diptera Collected in Itumbiara, Goiás / 5.1. Method Used (1)

A total of 2,048 dipteran pupae were collected from different substrates, including bovine kidney, chicken viscera, human feces, fish, and liver. From these, 737 specimens of *N. vitripennis* were obtained. The overall percentage of parasitism was relatively low, around 2.8%, 57 parasitized pupae out of 2,048 (Table 9).

Table 9: It highlights the percentage of parasitism, host distribution, and the influence of substrate on parasitoid occurrence of *Nasonia vitripennis*

Substrate	Host	Total pupae	*N. vitripennis*/ individuals	Parasitized pupae	Percentage
Bovine kidney	*Chrysomya albiceps*	420	276	12	2.9
Chicken viscera	*Musca domestica*	158	5	1	0.6
	Oxysarcodexia thornax	33	25	2	6.1
	Peckia chrysostoma	384	24	2	0.5
Fish	*Chrysomya albiceps*	43	40	3	7.0
	Peckia chrysostoma	85	16	3	3.5
Human feces	*Peckia chrysostoma*	106	5	1	0.9
	Sarcodexia lambens	42	8	2	4.8
Liver	*Chrysomya albiceps*	501	184	20	4.0
	Chrysomya megacephala	130	115	6	4.6
	Oxysarcodexia thornax	154	32	4	2.6
	Synthesiomyia nudiseta	109	7	1	0.9
Total and (%)		**2165**	**737**	**57**	**7.9**

Among the substrates, bovine liver showed the highest attraction for *N. vitripennis*, accounting for 45.9% of the parasitoids collected, as well as the greatest diversity of parasitized dipteran species. The highest parasitism rate was observed in *C. albiceps* collected from fish (7.0%), followed by *O. thornax* from chicken viscera (6.1%), *S. lambens* from human feces (4.8%), and *C. megacephala* from liver (4.6%). Host preference varies according to substrate type. In bovine kidneys, *N. vitripennis* showed a preference for *C. albiceps*. In chicken viscera, it preferred *P. chrysostoma* and *M. domestica*. In fish and human feces, the parasitoid was associated mainly with Sarcophagidae hosts (Figure 5).

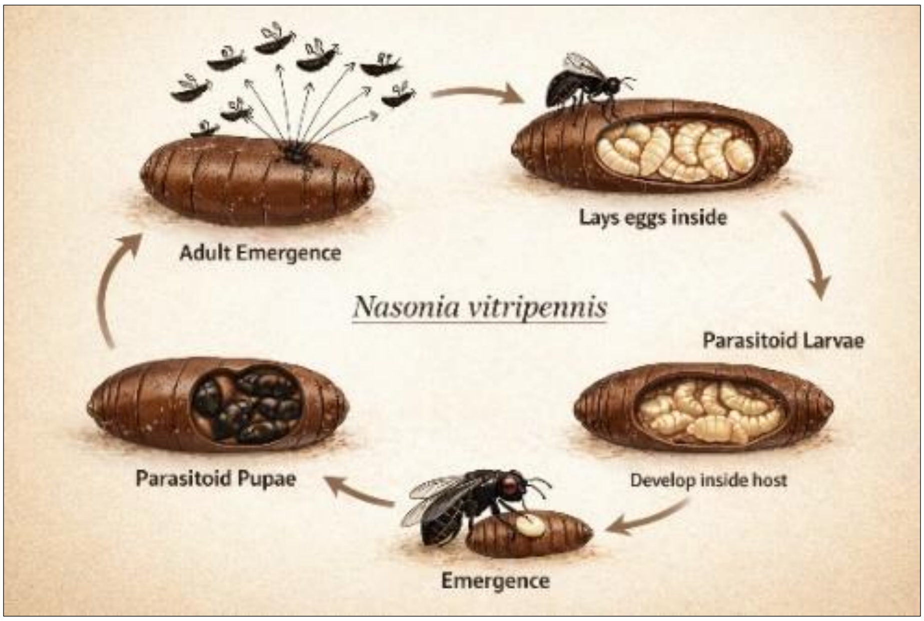

Figure 5: Life cycle of the parasitoid *Nasonia vitripennis*. Development occurs within the host pupa from egg to adult stage. Multiple adults emerge from a single parasitized puparium

In bovine kidneys, *N. vitripennis* showed a preference for *C. albiceps*. On the chicken substrate, *N. vitripennis* preferred *P. chrysostoma* and *M. domestica*. On fish, *N. vitripennis* showed a preference for *C. albiceps* and *P. chrysostoma*. In human feces, *N. vitripennis* preferred pupae of *P. chrysostoma* and *Sarcodexia lambens* (Walker) (Diptera: Sarcophagidae). In the liver, *N. vitripennis* showed a preference for *C. albiceps*, *O. thornax*, and *Synthesiomyia nudiseta* (Wulp) (Diptera: Muscidae) ($\chi^2 = 2764.2$; df = 24; $P < 0.05$). The variation in parasitism rates among substrates indicates that host availability and environmental conditions strongly influence parasitoid behavior. The higher abundance of *N. vitripennis* in bovine liver suggests that this substrate provides favorable conditions for host development and parasitoid attraction.

The high parasitism observed *in C. albiceps, O. thornax, S. lambens,* and *Chrysomya megacephala* (Fabricius, 1794) (Diptera: Calliphoridae) demonstrates that these hosts are suitable for the development of *N. vitripennis*, reinforcing their importance in parasitoid-host dynamics. The ability of this parasitoid to exploit multiple hosts across different substrates highlights its polyphagous nature and ecological adaptability. Differences in host preference among substrates may be related to factors such as host density, substrate decomposition stage, and resource quality. These findings support the role of *N. vitripennis* as a significant natural enemy of the synonyms of Diptera and its potential application in biological control programs (Marchiori, 2004b).

6. Hymenopterous Parasitoids of *Anastrepha* spp. Larvae in Star Fruit in Divinopolis, Minas Gerais, Brazil / 6.1. Method used (2)

A total of 304 pupae of *Anastrepha* spp. were collected from star fruit, *Averrhoa carambola* (Oxalidales: Oxalidaceae), from which 45 parasitoid specimens emerged, belonging to six species. The most abundant species was *Trichopria anastrepha* Costa Lima, 1949 (Hymenoptera: Diapriidae), accounting for 44.5% of the total parasitoids. Other parasitoid species included *Leptopilina boulardi* (Barbotin, Carton & Kelner-Pillault 1979) (Hymenoptera: Figitidae) (22.3%), *S. endius* (13.3%), *D. areolatus* (11.1%), *Odontosema anastrephae* Borgmeier, 1935 (Hymenoptera: Figitidae) (4.4%), and *P. vindemmiae* (4.4%) (Figure 6).

Figure 6: A female of *Trichopria anastrephae*, parasitoid of fruit fly larvae. Source: Poster Juliana Bah\355a Brasil.ppt

The overall parasitism rate was 14.8%. Among the species, *T. anastrepha* showed the highest parasitism rate (6.5%), indicating its dominance in the parasitoid community associated with fruit flies. The observed parasitism rate suggests that parasitoids play an important role in the natural regulation of fruit fly populations in the region studied. This rate may be influenced by factors such as host density, sampling effort, and environmental characteristics (Table 10).

Table 10: This table presents the parasitoid species associated with *Anastrepha* spp. collected in star fruit. It highlights species frequency, parasitism rates, and their relative importance in the studied area

Host	Pupae	Parasitoid	Frequency	Frequency (%)	Parasitism (%)
Anastrepha spp.	304	*Doryctobracon areolatus*	5	11.1	1.6
		Leptopilina boulardi	10	22.3	3.3
		Odontosema anastrepha	2	4.4	0.7
		Pachycrepoideus vindemmiae	2	4.4	0.7
		Spalangia endius	6	13.3	2.0
		Trichopria anastrepha	20	44.5	6.6
Total	**304**		**45**	**100**	**14.8**

The dominance of *T. anastrepha* indicates its strong adaptation and efficiency as a parasitoid of *Anastrepha* spp., likely due to its host-searching ability and ecological flexibility. Its high frequency reinforces its potential use in biological control programs (Figure 7).

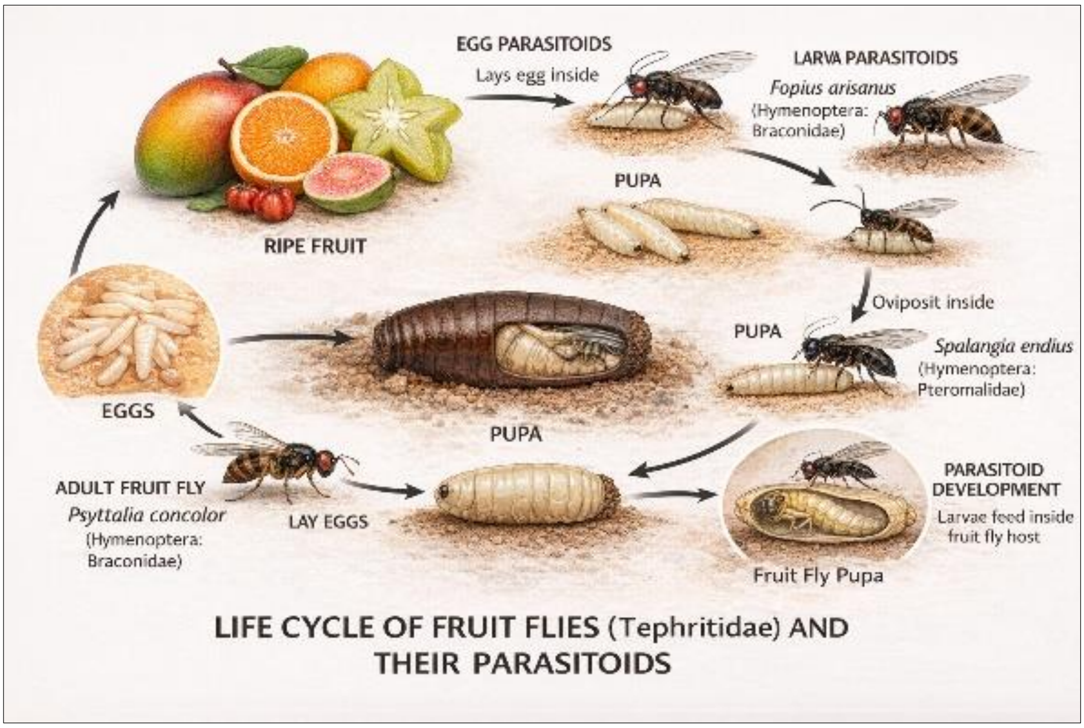

Figure 7: Life cycle of fruit flies, Tephritidae, and their parasitoids. Development from egg, larva, pupa to adult, associated with the host fruit. Parasitoids attack different stages, developing inside host larvae or pupae

Other parasitoids, such as *D. areolatus* and *P. vindemmiae*, are also important due to their known roles in parasitizing fruit fly larvae and pupae. The diversity of parasitoid species observed highlights the complexity of host–parasitoid interactions in fruit ecosystems. Overall, the results contribute to the understanding of parasitoid distribution and support their application in integrated pest management strategies (Siva *et al.,* 2003).

7. Parasitoids *Musca Domestica* from Itumbiara, Goiás, Brazil / 7.1. Method used (4)

A total of 44 parasitoids associated with *M. domestica* were recorded. The most frequent species was *P. vindemmiae* (38.6%), followed by *S. cameroni* (27.3%), *S. endius* (18.2%), *S. nigroaenea* (13.6%), and *S. nigra* (2.3%). The overall parasitism rate was low, not exceeding 0.2% in any species, indicating a limited impact of these parasitoids under the studied conditions (Table 11).

Table 11: This table presents the main parasitoid species associated with *Musca domestica* and their occurrence. It highlights their ecological roles and importance as natural enemies in synanthropic environments

Parasitoid species	Number	Percentage (%)	Parasitism (%)
Pachycrepoideus vindemmiae	17	0.2	38.6
Spalangia cameroni	12	0.2	27.3
Spalangia endius	8	0.1	18.2
Spalangia nigra	1	0	2.3
Spalangia nigroaenea	6	0.1	13.6
Total	**44**	**-**	**-**

Regarding frequency, *P. vindemmiae* was the most abundant species, accounting for 38.6% of the collected parasitoids, followed by *S. cameroni* with 27.3%. Together, these two species comprised most of the parasitoid community. The low parasitism rate observed may be associated with the structural characteristics of the poultry house, particularly the presence of lateral walls and mesh, which may have limited the access of parasitoids to the substrate (Figure 8).

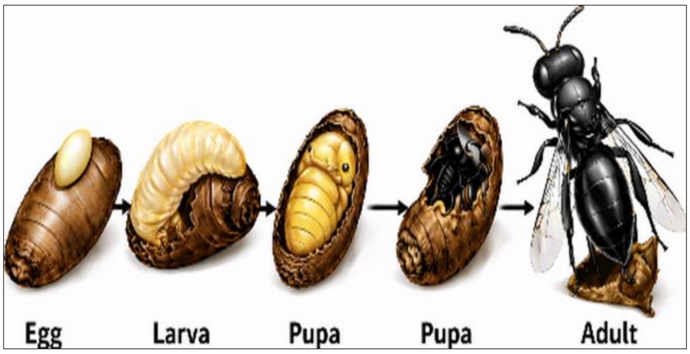

Figure 8: Life cycle of *Spalangia cameroni* parasitizing *Musca domestica* pupae. Oviposition occurs on the puparium, followed by internal larval development and consumption of the host. Adult parasitoids emerge, completing the cycle and regulating fly populations

Musca domestica is of immense importance in public health due to its synanthropic behavior, high reproductive capacity, and ability to develop in various substrates, as well as its role as a mechanical vector of pathogens affecting humans and animals. The identification of parasitoids associated with *M. domestica* is essential for the development of integrated control strategies. Parasitoids, especially those belonging to Pteromalidae, play a significant role in regulating fly populations, acting as solitary or gregarious ectoparasitoids of Diptera pupae.

The genus *Spalangia* includes pupal parasitoids associated with flies of several families, including Muscidae, Calliphoridae, Sarcophagidae, Drosophilidae, and Chloropidae, which develop in manure and animal carcasses. *Pachycrepoideus vindemmiae*, in turn, is a solitary parasitoid with a wide host range and broad geographic distribution, occurring in different regions worldwide. These results reinforce the importance of parasitoids as natural regulators of synanthropic fly populations and highlight their potential application in biological control programs (Marchiori *et al.*, 2003b).

8. *Brachymeria Podagrica* Collected in Brazil / 8.1. Method used (1)

A total of 2,430 Diptera pupae were collected, of which 395 specimens of *B. podagrica* emerged, resulting in an overall parasitism rate of 16.2%. The relatively high parasitism rate observed is likely related to factors such as host density, availability of resources, and the search efficiency of the parasitoid. These factors are known to directly influence parasitoid success in natural environments. *Brachymeria podagrica* is widely distributed worldwide and is commonly associated with synanthropic Diptera, developing in pupae (Figure 9).

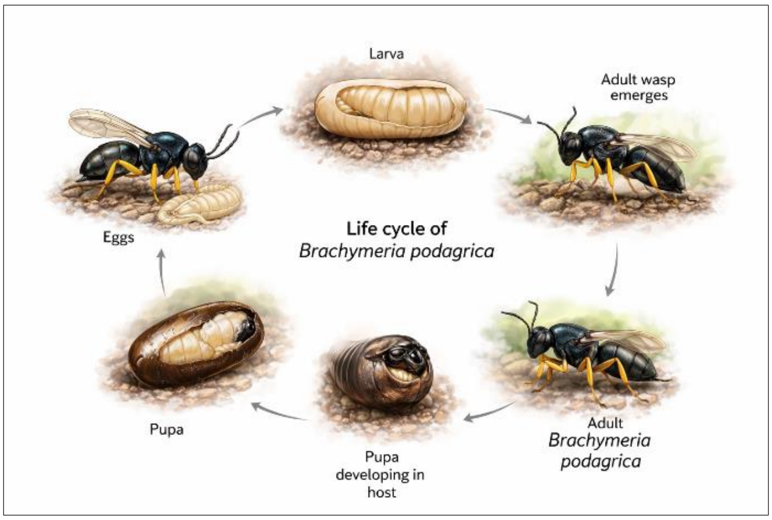

Figure 9: Life cycle of *Brachymeria podagrica.* Development occurs within the host pupa from egg to adult stage. Adult parasitoid emerges after completing development inside the host

A total of 2,430 dipteran pupae were collected, of which 395 were parasitized, resulting in an overall parasitism rate of 16.3%. The highest parasitism rate was observed in *C. albiceps* (45.0%), followed by *P. chrysostoma* (18.5%) and *S. lambens* (18.4%). Lower parasitism rates were recorded for *O. thornax* (6.2%), *Hemilucilia* sp. (Diptera Calliphoridae) (7.0%), *C. megacephala* (5.3%), and *Ophyra* sp. (3.8%), indicating variation in host susceptibility to *B. podagrica* across different taxonomic groups (Table 12).

Table 12: This table presents the dipteran host species associated with *Brachymeria podagrica*. It highlights host distribution, frequency, and parasitism patterns across different substrates

Taxonomic group	Host species	Number of pupae	Parasitized pupae	Parasitism (%)
Calliphoridae	*Chrysomya albiceps*	20	9	45.0
	Chrysomya megacephala	19	1	5.3
	Hemilucilia flavifacies	43	3	7.0
Muscidae	*Ophyra* sp.	26	1	3.8
Sarcophagidae	*Oxysarcodexia thornax*	390	24	6.2
	Peckia chrysostoma	1324	245	18.5
	Sarcodexia lambens	608	112	18.4
Total	**-**	**2430**	**395**	**16.3**

Chrysomya megacephala is also of medical importance, frequently associated with decomposing organic matter and urban environments, being attracted to substrates such as blood, wounds, and decomposing materials. The results contribute to the knowledge of the bioecology and geographic distribution of parasitoids associated with Diptera in Brazil. The use of parasitoids as natural enemies represents a promising alternative to chemical insecticides, especially considering the development of resistance in dipteran populations (Marchiori, 2019a).

9. Parasitoids of Fruit Flies Collected in Brazil / 9.1. Method used (2)

A total of 45 parasitoids were recorded in western Minas Gerais and 48 in southern Goiás. In western Minas Gerais, the most frequent species was *T. anastrephae* (n = 20), followed by *L. boulardi* (n = 10) and *S. endius* (n = 6). In southern Goiás, *D. areolatus* was the most abundant species (n = 43), followed by *A. pelleranoi* (n = 3) and *P. vindemmiae* (n = 2). The results indicate differences in species composition between regions, reflecting variation in parasitoid distribution associated with fruit fly hosts.

Trichopria anastrephae is a generalist species commonly found in Brazil, typically developing as a solitary parasitoid within host pupae. Although several diapriid species parasitize Diptera, only a few are known to attack Tephritidae. In southern Goiás, *D. areolatus* was the dominant species, accounting for 89.6% of the parasitoids collected. This predominance may be associated with its efficiency in parasitizing larvae at earlier developmental stages, providing a competitive advantage over other parasitoid species (Table 13). In pastures, *A. notula*, *P. egeria*, and *Trichopria* sp. showed a preference for *S. occidua* pupae (χ^2 = 86.85; GL=24; P=36.42), while in corrals, *Muscidifurax raptorellus* Kogan & Legner, 1970 (Hymenoptera: Pteromalidae), *N. splendens, Paraganaspis egeria* Diaz, Gallardo & Wash (Hymenoptera: Figitidae), and *S. nigroaenea* showed a preference for *S. occidua* pupae (χ^2 =225.56; df=18; P= 28.87) (Table 13).

Table 13: This table presents the main parasitoid species associated with fruit flies in Brazil. It highlights host associations, parasitism rates, and species distribution across regions. The data also emphasizes their importance in biological control programs

Taxonomic Group	West of MG	Southern GO
Aganaspis pelleranoi	0	3
Doryctobracon areolatus	5	43
Leptopilina boulardi	10	0
Odontosema anastrepha	2	0
Pachycrepoideus vindemmiae	2	2
Spalangia endius	6	0
Trichopria anastrephae	20	0
Total	**45**	**48**

Doryctobracon areolatus is a solitary endoparasitoid that oviposits in larval stages, with adult emergence occurring from host pupae. It is widely reported as one of the most common parasitoids associated with fruit flies in Brazil. The total parasitism rate was higher in western Minas Gerais (14.8%) than in southern Goiás (5.5%). This difference may be associated with environmental factors, including lower synanthropy in the Goiás sampling area, which is surrounded by human populations. In western Minas Gerais, *T. anastrephae* showed the highest parasitism rate (6.6%), whereas in southern Goiás, the highest value was observed for *D. areolatus* (5.0%). Parasitism of *A. fraterculus* in guava, *Psidium guajava* L. 1753 (Myrtales: Myrtaceae) reached 5.8%. Other parasitoid species, such as *Utetes anastrephae* (Viereck, 1913) (Hymenoptera, Braconidae) and *A. anastrephae*, also contribute to the natural control of fruit flies, as reported in other regions of Brazil (Figure 10).

Figure 10: *Anastrepha fraterculus, a* fruit fly species, is native and most common in South America, but can also be found in Central America and North America. biochemtech.eu

Table 2 presents the percentage of parasitism by different parasitoid species associated with *Anastrepha* spp. in the western region of Minas Gerais (MG) and southern Goiás (GO), Brazil. In Minas Gerais, the highest parasitism rate was observed for *T. anastrephae* (6.6%), indicating that this species plays a more significant role in this region. In contrast, in southern Goiás, *D. areolatus* showed the highest parasitism rate (5.0%), highlighting its importance as a natural enemy of fruit flies in that area.

Other species exhibited low parasitism levels or were absent in one or both regions. For example, *A. pelleranoi* and *Odontosema anastrephae* Borgmeier 1935 (Hymenoptera: Figitidae) showed no parasitism in Goiás. Overall, the total parasitism rate was higher in Minas Gerais (14.8%) compared to Goiás (5.5%), suggesting differences in ecological conditions, host availability, or environmental factors between the two regions. These findings emphasize the importance of parasitoids as biological control agents and demonstrate regional variation in species composition and parasitism efficiency (Table 14).

Table 14: Percentage of parasitism by parasitoids collected in *Anastrepha* spp. in the southern regions of Goiás and western Minas Gerais, Brazil

Families / Species	**Parasitism (%) MG**	**Parasitism (%) GO**
Doryctobracon areolatus	1.6	5.0
Diapriidae		
Trichopria anastrephae	6.6	0
Figitidae		
Aganaspis pelleranoi	0	0
Lopheucoila anastrephae	3.3	0.5
Odontosema anastrephae	0.7	0
Pteromalidae		
Pachycrepoideus vindemmiae	0.7	0
Spalangia endius	2.0	0
Total	**14.8**	**5.5**

These results demonstrate that parasitoids play a significant role as natural regulators of fruit fly populations and may be used as biological control agents in agricultural systems (Marchiori, 2019b).

10. *Hemencyrtus Herbertii* in *Musca Domestica* in Brazil / 10.1. Method used (1)

A total of 115 pupae were obtained, of which 13 corresponded to *M. domestica* collected from human feces. From these pupae, five adult flies emerged, while seven did not produce either adult flies or parasitoids, due to natural mortality of the host. From one pupa, five gregarious parasitoids of the species *H. herbertii* emerged. *Musca domestica* is the species of greatest sanitary concern due to its synanthropic nature, its endophilin, abundance in urban areas, ability to develop in several types of substrates, high reproductive capacity, and being identified as a vector of pathogens to humans and animals.

The occurrence of multiple parasitoids emerging from a single host indicates polyembryony, a characteristic observed in several species of Encyrtidae, in which numerous individuals develop within the same host. The percentage of parasitism was 0.9% based on the total number of pupae collected, and reached 7.7% when considering only pupae of *M. domestica*. These values indicate a low level of parasitism under the conditions studied (Figure 11).

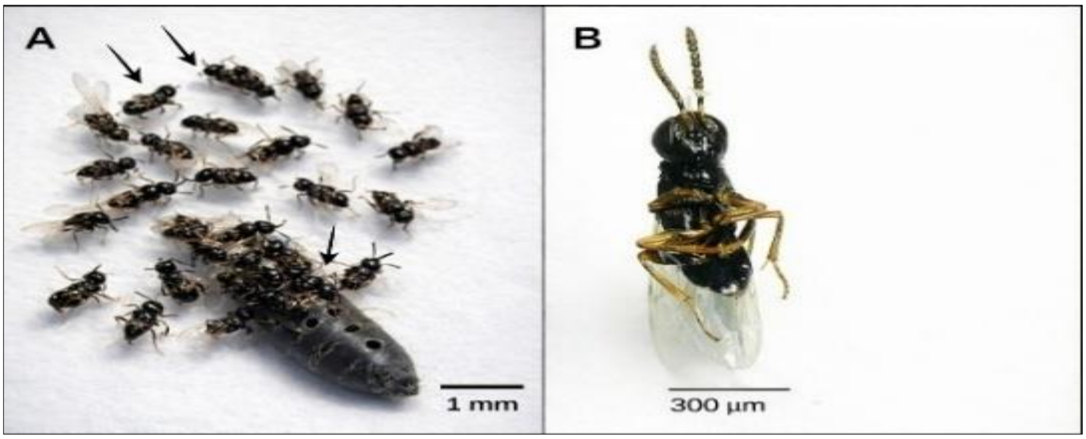

Figure 11: Gregarious parasitoid emergence from a dipteran host. (A) Multiple individuals emerging from a single pupa, indicating gregarious development. (B) Adult parasitoid *Hemencyrtus herbertii* in lateral view

Hemencyrtus herbertii was also recorded parasitizing other dipteran hosts, including *C. albiceps*, *S. nudiseta*, and *Oxysarcodexia* sp., demonstrating a broad host range. The results highlight the importance of *H. herbertii* as a natural enemy of synanthropic flies, particularly *M. domestica*, which is of great sanitary importance due to its role as a mechanical vector of pathogens. Considering the relevance of these insects in public health, studies on parasitoid species are essential to support integrated control strategies and to reduce fly populations through biological control methods (Marchiori *et al.*, 2002).

11. Biodiversity of Parasitoids Collected in Goiás, Brazil / 1.1. Method used (4)

A total of 96 parasitoids were recorded, with 52 individuals collected in forest areas and 44 in pasture environments. The most abundant species was *Zaeucoila* sp. (n = 35), followed by *K. nigra* (n = 15) and *Trybliographa* sp. (n = 14). Some species, such as *Trybliographa* sp., showed a preference for forest environments, while others, including *Dicerataspis* sp. and *Aganaspis* spp., were more frequently found in pasture areas. These results indicate differences in parasitoid distribution according to habitat type (Table 15).

Table 15: It highlights their distribution, frequency, and association with dipteran hosts in organic substrates. The data also emphasize their ecological importance as natural enemies and their role in maintaining ecosystem balance

Taxonomic Group	Forest	Pasture	Total
Aganaspis pelleranoi	0	2	2
Aganaspis sp.	0	1	1
Dicerataspis sp.	0	3	3
Lopheucoila sp.	1	1	2
Kleidotoma nigra	5	10	15
Braconidae sp.	9	1	10
Paraganaspis egeria	5	5	10
Trybliographa sp.	8	6	14
Trybliographa spp.	4	0	4
Zaeucoila sp.	20	15	35
Total	52	43	96

A greater number of individuals was recorded in the forest area, indicating that this environment may act as an important reservoir of parasitoids, which function as natural enemies of insects, many of them of economic importance. The most frequent species in both environments was *Zaeucoila* sp., representing 53.6% of the individuals collected in the forest and 46.4% in the pastures. This species acts as a parasitoid of Agromyzidae (Diptera) (Figure 12).

Figure 12: Species *Zaeucoila* sp. This species likely acts as a parasitoid of Agromyzidae (Diptera). Iowa State University, unless otherwise noted

D = Nmax/N, where N is the total number of individuals and Nmax is the number of individuals of the most abundant species. was similar between the two environments, with values of 0.3 in pastures and 0.4 in the forest. This similarity may be explained by the proximity between the pasture and the fragment of natural vegetation, which provides a wide diversity of host plants and supports a broader range of natural enemies. The diversity of Eucoilinae species was higher in pastures, due to the presence of hosts associated with animal feces. Comparisons with other studies indicate that forest environments tend to present slightly higher diversity indices, reinforcing the importance of preserved habitats for maintaining parasitoid biodiversity. In the current agricultural scenario, habitat destruction and fragmentation caused by the expansion of cultivated areas are the main factors responsible for changes in biodiversity (Marchiori, 2019c).

12. Parasitoids of *Sarcophagula Occidua* Collected in Cattle Dung in Goiás/ 12.1. Method used (4)

The study evaluated parasitoids associated with *S. occidua* in bovine dung collected from pasture and cattle corrals in Itumbiara, Goiás. A greater diversity of parasitoid species was observed in pasture environments compared to corrals. The most frequently collected parasitoids belonged to the families Pteromalidae and Eucoilinae. Among them, *P. egeria* was the predominant species, presenting the highest parasitism rates in both environments 1.6% in pastures and 0.6% in corrals) (Figure 13).

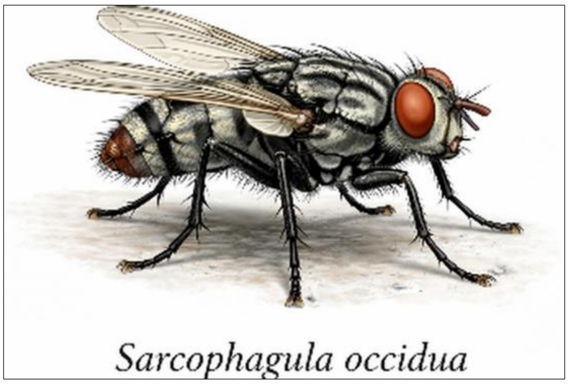

Figure 13: Lateral view of *Sarcophagula occidua*, highlighting its morphological characteristics and taxonomic features. This species is commonly associated with decomposing organic matter and plays a role in nutrient recycling

A total of 2,006 pupae of *S. occidua* were collected, from which 87 parasitoids emerged, resulting in an overall parasitism rate of 4.3%. The most frequent species was *P. egeria* (1.6%), followed by *S. drosophilae* (0.9%) and *S. nigroaenea* (0.5%). The remaining species showed lower parasitism rates, ranging from 0.1% to 0.4%, indicating a relatively low but diverse parasitoid community associated with this host in pasture environments. In pastures, *A. notula*, *P. egeria*, and *Trichopria* sp. showed a preference for *S. occidua* pupae (χ^2 = 86.85; GL=24; P=36.42), while in corrals, *M. raptorellus*, *N. splendens, P. egeria*, and *S. nigroaenea* showed a preference for *S. occidua* pupae (χ^2 =225.56; df=18; P= 28.87) (Table 16).

Table 16: Relation of parasitoid occurrence and percentage of parasitism of Sarcophagula occidua in pasture area in the municipality of Itumbiara, Goias, Brazil

Hosts and number of pupae	Parasitoids	Frequency	Percentage of parasitism
Sarcophagula occidua (2006)	*Aleochara notula*	3	0.2
	Muscidifurax raptorellus	1	0.1
	Neralsia splendens	0	0.1
	Paraganaspis egeria	31	1.6
	Spalangia cameroni	8	0.4
	Spalangia drosophilae	17	0.9
	Spalangia endius	4	0.2
	Spalangia nigroaenea	10	0.5
	Trichopria sp.	08	0.4
	Triplasta atrocoxalis	4	0.2
Total		**87**	**4.3**

A total of 4,521 pupae of *S. occidua* were collected, from which 62 parasitoids emerged, resulting in an overall parasitism rate of 1.4%. The most frequent species was *P. egeria* (0.6%), followed by *N. splendens* (0.3%) and *P. vindemmiae* (0.2%). The remaining species, including *M. raptorellus*, *S. cameroni*, and *S. nigroaenea*, showed lower parasitism rates (0.1%), indicating a low level of parasitism in corrals despite the presence of multiple parasitoid species (Table 17).

Table 17: Relation of parasitoid occurrence and percentage of parasitism of *Sarcophagula occidua* in corrals in the municipality of Itumbiara, Goias, Brazil

Hosts and number of pupae	Parasitoids	Frequency	Parasitism
Sarcophagula occidua (4521)	*Muscidifurax raptorellus*	4	0.1
	Neralsia splendens	14	0.3
	Pachycrepoideus vindemmiae	11	0.2
	Paraganaspis egeria	26	0.6
	Spalangia cameroni	4	0.1
	Spalangia nigroaenea	3	0.1
Total		**62**	**1.4**

Differences in parasitoid composition between pasture and corral environments may be influenced by factors such as host density, substrate characteristics, and management practices. The lower parasitism rates observed in corrals may reflect reduced habitat suitability or higher environmental stress. Overall, the results demonstrate that parasitoid communities play a significant role in regulating populations of dung-breeding Diptera and may contribute to integrated pest management strategies (Marchiori, 2000b).

13. Hosts of the Parasitoid *Paraganaspis Egeria* Were Collected in Bovine and Buffalo Feces in the South of the State of Goiás / 13.1. Method used (4)

Were collected from bovine feces, from which 53 specimens of *P. egeria* emerged, resulting in a parasitism rate of 0.5%. In buffalo feces, 3,473 pupae were collected from which 28 specimens of *P. egeria* emerged, corresponding to a parasitism rate of 0.8% (Figure 14).

Figure 14: Female. (1) antenna; (2) pronotal plate; (3) mesonotum and scutellum; (4) detail of the radial cell (anterior wing). Male. (5) Detail of the antenna. Source: Photo#2497577/Steve Scholnick

The parasitism rates observed were low and may be associated with variations in resource availability, host density, and environmental conditions. For bovine feces, the parasitoid was associated with several hosts. The highest parasitism rate was observed in *H. irritans* (3.6%), followed by *Palaeosepsis* sp. (1.9%) and *S. occidua* (1.7%). Lower parasitism rates were recorded for *C. pararescita* (0.7%) and *B. quadristigma* (0.1%). In buffalo feces, *P. egeria* parasitized *Archisepsis scabra* (Loew 1861) (Diptera: Sepsidae) (1.3%), *S. occidua* (1.2%), *B. quadristigma* (0.7%), and *Palaeosepsis* spp. (0.6%). Overall, the parasitism rate was low for all hosts, remaining below 3.6%, indicating limited impact under the conditions studied (Table 18).

Table 18: It highlights variations in parasitism rates between bovine and buffalo feces and host preference patterns. The data also emphasize the ecological role of this parasitoid as a natural regulator of dung-breeding Diptera populations

Substrate	Host species	Number of pupae	Number of parasitoids	Parasitism (%)
Bovine feces	*Archisepsis scabra*	310	4	1.3
	Brontaea sp.	138	1	0.7
	Cyrtoneurina pararescita	302	2	0.7
	Haematobia irritans	28	1	3.6
	Sarcophagula occidua	2833	47	1.7
Total		**3611**	**55**	**1.5**
Buffalo feces	*Archisepsis scabra*	310	4	1.3
	Palaeosepsis spp.	1948	12	0.6
	Sarcophagula occidua	931	11	1.2
Total		**3189**	**27**	**0.8**

These results suggest that natural regulators such as parasitoids can contribute to the control of synanthropic flies. Several species of Eucoilinae are reported as important natural enemies of dipterans and may be used in biological control programs. This study contributes to the knowledge of the bioecology of *P. egeria* in Brazil, particularly regarding its host range and occurrence (Marchiori, 2009).

14. Hosts of *Triplasta Atrocoxalis* Collected in Bovine and Buffalo Feces in Brazil / 14.1. Method used (4)

A total of 6,618 Diptera pupae were collected, from which 134 solitary parasitoids of *T. atrocoxalis* emerged, resulting in an overall parasitism rate of 2.0%. In bovine feces, the parasitism rate was 2.5%, whereas in buffalo feces it was only 0.1%. The lower parasitism rate and reduced host diversity observed in buffalo feces may be associated with the recent introduction of buffalo into the Itumbiara region, Goiás, as well as with a lower sampling effort. Among the hosts collected in bovine feces, *Palaeosepsis* spp. presented the highest parasitism rate (6.3%), followed by *A. scabra* (6.2%). Lower parasitism rates were observed for Sphaeroceridae sp. (2.7%) and *S. occidua* (0.2%) (Figure 15).

Figure 15: *Palaeosepsis* spp. They are small flies, measuring between 2 and 6 mm. Typically, the head is spherical, the body dark, and the abdomen is petiolate. Females use animal feces and decaying plants as a breeding substrate

The higher parasitism observed in *Palaeosepsis* spp. may be related to differences in host density, food availability, or substrate conditions that favor parasitoid development. In buffalo feces, only *Palaeosepsis* spp. was recorded as host, with a parasitism rate of 0.1%, indicating a more limited parasitoid-host interaction in this substrate (Table 19).

Table 19: This table presents the dipteran host species associated with *Triplasta atrocoxalis* in different dung substrates. It highlights variations in parasitism rates and host preferences between cattle and buffalo feces

Substrate	Host species	Number of pupae	Parasitized pupae	Parasitism (%)
Bovine feces	*Archisepsis* scabra	129	8	6.2
	Palaeosepsis spp.	1611	101	6.3
	Sphaeroceridae sp.	37	1	2.7
	Sarcophagula occidua	2893	5	0.2
Total	**-**	**4670**	**115**	**2.5**

The low parasitism rates observed suggest that environmental conditions, host availability, and ecological factors may influence the efficiency of *T. atrocoxalis* as a natural enemy. Despite this, parasitoids in the family Cynipidae are important regulators of dipteran populations developing in manure, and their study contributes to understanding the potential for biological control in livestock environments. This study expands the knowledge of the bioecology of parasitoids associated with dung-breeding Diptera in Brazil (Marchiori, 2008a).

15. Parasitoids of Muscoid Diptera Collected at the Slaughterhouse in Itumbiara, Southern Goiás, Brazil / 15.1. Method (1)

A total of 1,411 pupae of muscoid Diptera were collected, from which 960 parasitoids emerged from 216 parasitized pupae, resulting in an overall parasitism rate of 15.3%. Among the parasitoid species, *B. podagrica* was the most frequent, accounting for 80.1% of the parasitized pupae. This high frequency is likely related to its polyphagous behavior and wide geographic distribution, as well as its strong association with synanthropic Diptera. Other parasitoids recorded included *Aphaereta* sp. (2.3%), *N. vitripennis* (15.7%), *P. vindemmiae* (0.5%), *Spalangia* sp. (0.9%), and *Trybliographa* sp. (0.5%) (Figure 16).

Figure 16: Life cycle of a gregarious parasitoid *Aphaereta*, with multiple individuals developing within a single host pupa. Larvae consume the host internally, allowing simultaneous development of several parasitoids. Adults emerge together, completing the cycle and contributing to host population regulation

A total of 1,411 dipteran pupae were reported, from which 960 parasitoids emerged, resulting in an overall parasitism rate of 15.3%. The highest parasitism rates were observed in *B. podagrica* associated with *P. chrysostoma* (20.3%) and *S. lambens* (18.8%), as well as in *N. vitripennis* associated with *C. albiceps* (16.1%). Lower parasitism rates were recorded for other host–parasitoid associations, generally below 10%. However, discrepancies between the total number of pupae and the sum of individual host records suggest the need for careful interpretation of these results (Table 20).

Table 20: This table presents the parasitoid species associated with muscoid Diptera collected in a slaughterhouse environment. It highlights their frequency, parasitism rates, and host associations in substrates rich in organic matter

Diptera species	Number of pupae	Parasitoid species	Parasitoids Number	Parasitized pupae (%)
Chrysomya albiceps	93	*Nasonia vitripennis*	198	15
Chrysomya megacephala	163	*Brachymeria podagrica*	1	0.6
		Nasonia vitripennis	18	1.2
Musca domestica	180	*Spalangia* sp.	2	1.1
Oxysarcodexia thornax	11	*Brachymeria podagrica*	1	9.1
		Trybliographa sp.	1	9.1
Peckia chrysostoma	340	*Aphaereta* sp.	198	0.9
		Brachymeria podagrica	69	20.3
		Nasonia vitripennis	321	3.5
Sarcodexia lambens	543	*Aphaereta* sp.	7	0.4
		Brachymeria podagrica	102	18.8
		Nasonia vitripennis	41	0.9
		Pachycrepoideus vindemmiae	1	0.2
Total	**1330**	**-**	**960**	**15.3**

Brachymeria podagrica showed the highest frequency of parasitism, particularly in *P. chrysostoma*, likely due to its high host-searching capacity. Host preference analysis indicated that *Aphaereta* sp. preferred *S. lambens*, *B. podagrica* preferred *O. thornax* and *S. lambens*, *N. vitripennis* preferred *C. albiceps* and *C. megacephala*, *P. vindemmiae* preferred *S. lambens*, *Spalangia* sp. preferred *M. domestica*, and *Trybliographa* sp. preferred *O. thornax* (χ^2 = 1897.17; df = 68; P < 0.05). These results highlight the importance of parasitoids as natural regulators of muscoid Diptera populations, particularly those of sanitary and veterinary importance. The identification of parasitoid-host associations is essential for the development of integrated control strategies. It supports the potential use of these natural enemies in biological control programs (Marchiori *et al.*, 2007a).

16. Parasitoids of *Oxysarcodexia Thornax* Collected in the State of Goiás, Brazil / 16.1. Method used (1)

A total of 100 pupae were collected, of which 57 were infested, resulting in an overall infestation rate of 57.0%. The highest infestation rate was observed in human feces (86.9%), followed by fish (54.8%) and bovine kidneys (43.5%). These results indicate that substrate type influences infestation levels, with human feces providing more favorable conditions for dipteran development in the studied environment (Table 21).

Table 21: Number of pupae collected, infested, and percentage of parasitism. This table presents the number of pupae collected and infested, as well as parasitism rates. It highlights variations in parasitism according to different substrates in the studied environment

Substrate	Collected	Infestation rate	Percentage for each Substrate
Human feces	23	20	86.9
Bovine kidneys	46	20	43.5
Fish	31	17	54.8
Total	**100**	**57**	**57.0**

These results demonstrate that *O. thornax* serves as a host for multiple parasitoid species, highlighting its ecological importance in parasitoid-host interactions. The relatively high parasitism rate suggests that these parasitoids may play a significant role in regulating populations of this dipteran species (Figure 17) (Table 22).

Table 22: Parasitoid species and percentage. This table presents the parasitoid species collected and their respective percentage

Parasitoid	Number of individuals	Frequency (%)
Gnathopleura quadridentata	20	35.1
Brachymeria podagrica	11	19.3
Hemencyrtus sp.	10	17.5
Pachycrepoideus vindemmiae	16	28.1
Total	**57**	**100**

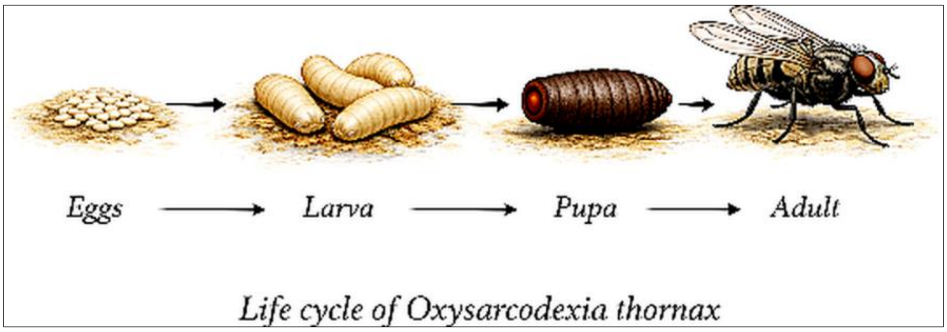

Figure 17: Life cycle of *Oxysarcodexia thornax*, showing the sequential development from eggs to larval, pupal, and adult stages. Larvae develop on decomposing organic substrates before transitioning to the pupal stage

Additionally, this study represents the first record of *B. podagrica*, *Hemencyrtus* sp., and *P. vindemmiae* parasitizing *O. thornax* in Brazil. These findings reinforce the importance of parasitoids as natural enemies of synanthropic flies and their potential use in biological control programs (Marchiori *et al.*, 2002a).

17. Parasitoids of Dipterans Collected in a Slaughterhouse in Tupaciguara, Minas Gerais, Brazil / 17.1. Method used (1)

A total of 1,652 Diptera pupae were collected, from which 411 parasitoid specimens emerged, indicating a total parasitism rate of 14.1%. Among the parasitoids, *P. vindemmiae* was the most abundant species, accounting for 82.4% of the parasitized pupae. This predominance is likely associated with its polyphagous behavior, wide geographic distribution, and high efficiency in host searching. Other parasitoid species recorded included *N. vitripennis* (128 individuals), *Hemencyrtus* sp. (75), *B. podagrica* (10), *S. endius* (5), and *Neralsia* sp. (1). The parasitism rates for each species were 0.6% for *B. podagrica*, 0.7% for *Hemencyrtus* sp., 0.8% for *N. vitripennis*, 0.1% for *Neralsia* sp., 11.6% for *P. vindemmiae*, and 0.3% for *S. endius* (Figure 18).

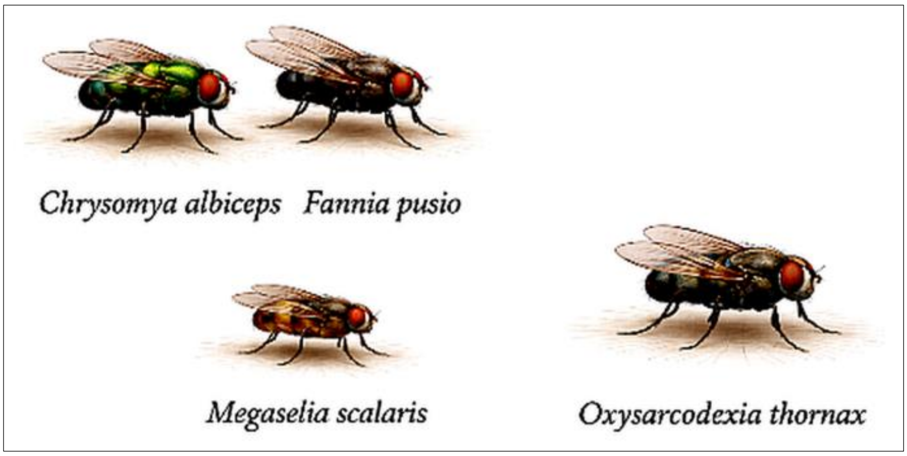

Figure 18: *Chrysomya albiceps* is distinguished by its metallic green coloration, while other species present darker or lighter tonal variations. These species play important roles in decomposition processes and ecological succession

A total of 1,652 dipteran pupae were collected, from which 377 parasitoids emerged, corresponding to 224 parasitized pupae. The highest levels of parasitism were observed in *F. pusio* and *M. scalaris*, both with 63 parasitized pupae associated with *P. vindemmiae*. In *M. domestica*, multiple parasitoid species were recorded, including *Hemencyrtus* sp., *P. vindemmiae*, and *S. endius*, totaling 72 parasitized pupae. Other host species, such as *C. albiceps*, *Ophyra* sp., and *O. thornax*, showed lower parasitism levels. These results highlight the diversity of parasitoid–host associations and their role in regulating synanthropic Diptera populations (Table 23).

Table 23: This table presents the parasitoid species and their associated dipteran hosts collected in the study area. It highlights parasitism rates, host preferences, and species distribution in different substrates. The data also emphasize the ecological role of parasitoids as natural regulators of synanthropic Diptera populations

Diptera species	Number of pupae	Parasitoid species	Number of parasitoids	Parasitized pupae
Chrysomya albiceps	74	*Hemencyrtus* sp.	20	3
Fannia pusio	428	*Pachycrepoideus vindemmiae*	64	64
Musca domestica	392	*Hemencyrtus* sp.	35	5
		Pachycrepoideus vindemmiae	63	63
		Spalangia endius	4	4
Megaselia scalaris	492	*Pachycrepoideus vindemmiae*	63	63
Ophyra sp.	64	*Hemencyrtus* sp.	20	3
Oxysarcodexia thornax	139	*Brachymeria podagrica*	8	8
		Neralsia sp.	1	1
Peckia chrysostoma	40	*Nasonia vitripennis*	82	4
		Pachycrepoideus vindemmiae	2	2
		Spalangia endius	1	1
Sarcodexia lambens	23	*Brachymeria podagrica*	2	2
		Nasonia vitripennis	12	1
Total	**1652**	**-**	**377**	**224**

Host preference analysis indicated that *B. podagrica* was associated with *O. thornax* and *S. lambens*, *Hemencyrtus* sp. with *C. albiceps*, *M. domestica*, and *Ophyra* sp., *N. vitripennis* with *C. albiceps*, *P. chrysostoma*, and *S. lambens*, *P. vindemmiae* with *F. pusio*, *M. domestica*, and *M. scalaris*, *Neralsia* sp. with *O. thornax*, and *S. endius* with *M. domestica* and *P. chrysostoma* (χ^2 = 471.08; df = 35; P < 0.05). These results highlight the importance of parasitoids as natural regulators of synanthropic Diptera populations and reinforce their potential application in biological control programs (Marchiori *et al.*, 2007b).

18. Parasitoids of Dipterans Collected Using Pitfall Traps in Itumbiara, Goiás / 18.1. Method used (3)

The study recorded a total of 803 dipteran pupae, from which 220 parasitoids emerged, resulting in an overall parasitism rate of 27.4%. Five parasitoid species were identified: *G. quadridentata*, *Neralsia* sp., *S. endius*, *S. nigroaenea*, and *Trybliographa* sp. Among these, *G. quadridentata* was the most abundant species, accounting for the highest parasitism rate (19.6%), followed by *Neralsia* sp. (5.4%). The remaining species exhibited low parasitism rates: *S. endius* (0.1%), *S. nigroaenea* (0.2%), and *Trybliographa* sp. (2.1%). Host association analysis revealed that *G. quadridentata* parasitized multiple dipteran species, particularly *P. chrysostoma* (35.7%) and *S. lambens* (17.0%). Other parasitoids showed more specific host associations, such as *Neralsia* sp. and *Trybliographa* sp. with *O. thornax*.

These environments likely enhance parasitoid diversity and abundance, contributing to higher parasitism levels. Despite the difference in the number of parasitoids collected in two traps, the attraction of the traps in relation to species of parasitoids (F = 0.4, P = 0.85) and the species of parasitoids (F = 0.93, P = 0.54) were not statistically significant. The relatively high parasitism rate (27.4%) observed in this study may be associated with environmental factors such as proximity to forested areas, which serve as reservoirs for parasitoid populations (Table 24).

Table 24: This table presents the parasitoid species and their associated dipteran hosts collected using pitfall traps. It highlights parasitism rates, host associations, and species distribution in the studied environment

Diptera species/group	Frequency	Parasitoid species	Number of parasitized pupae	Parasitism (%)
Archisepsis scabra	54	-	-	-
Fannia pusio	10	*Spalangia nigroaenea*	1	10
Musca domestica	50	-	-	-
Megaselia scalaris	54	-	-	-
Oxysarcodexia thornax	305	*Gnathopleura quadridentata*	75	24.6
		Neralsia sp.	43	14.1
		Trybliographa sp.	17	5.6
Peckia chrysostoma	143	*Gnathopleura quadridentata*	51	35.7
Sarcodexia lambens	182	*Gnathopleura quadridentata*	31	17
		Spalangia endius	2	1.1
Sarcophagula sp.	5	-	-	-
Total	**803**	**-**	**220**	**27.4**

The dominance of *G. quadridentata* suggests that this species has a strong capacity for host searching and adaptation to different hosts, reinforcing its potential as a biological control agent. Its polyphagous behavior allows it to exploit multiple dipteran species, increasing its ecological persistence. In contrast, the lower parasitism rates observed for other parasitoids may be related to differences in host specificity, reproductive strategies, or environmental constraints (Figure 19).

Figure 19: *Gnathopleura quadridentata* (Hymenoptera: Braconidae: Alysiinae). Source: National University of Colombia

The variation in parasitism rates among species indicates that both biotic and abiotic factors influence parasitoid efficiency. Overall, the findings highlight the importance of parasitoids as natural regulators of dipteran populations and support their potential application in integrated pest management programs (Marchiori *et al.,* 2007c).

19. Parasitoids of Diptera Collected in Forest, Rural, and Urban Areas in Monte Alegre, MG / 19.1. Method used (4)

A total of 372 dipteran pupae were collected across three environments: forest (91), rural (217), and urban (64). From these, 49 parasitoids emerged, distributed as 13 in the forest, 24 in rural areas, and 12 in urban areas. The most frequent parasitoid species was *T. atrocoxalis*, representing 34.7% *of* the total collected parasitoids. Other species included *K. nigra*, *P. egeria*, and *Trichopria* sp. (Figure 20).

Figure 20: Lateral view of *Kleidotoma nigra*, highlighting its slender body, reduced wing venation, and characteristic morphology of Eucoilinae

In forest areas, parasitoids associated with *A. scabra* included *K. nigra*, *P. egeria*, *T. atrocoxalis*, and *T. coxalis*, with parasitism rates of 2.0%, 2.0%, 11.8%, and 2.0%, respectively. In addition, *K. nigra* was also recorded parasitizing *Palaeosepsis* sp., with a parasitism rate of 25.0%. In rural areas, parasitoids associated with *A. scabra* included *Kleidotoma* sp. and *T. atrocoxalis* (13.3% each), while *K. nigra* parasitized *Palaeosepsis* sp. (8.9%) and *S. cameroni* parasitized *S. occidua* (20.0%). In urban areas, *Trichopria* sp. was associated with *B. quadristigma* (16.7%) and another dipteran host (24.4%). These results indicate variation in parasitoid–host associations across different environments.

The higher parasitism rate observed in urban areas may be associated with increased host density, favoring parasitoid efficiency. In contrast, forest environments exhibited moderate parasitism, possibly due to more stable ecological conditions and lower host concentrations. The predominance of *T. atrocoxalis* highlights its adaptability and importance as a natural enemy of dung-breeding Diptera (Table 25).

Table 25: Frequency of parasitoids, parasitoid species, number of parasitized pupae, and parasitism percentage of their hosts collected in forest, rural, and urban areas in Monte Alegre, Minas Gerais

Area	Taxonomic group	Frequency	Parasitoid species	Number of parasitized pupae	Parasitism %
Forest	*Archisepsis scabra*	51	*Kleidotoma nigra*	1	2.0
		45	*Paraganapis egeria*	1	2.0
		6	*Triplasta atrocoxalis*	6	11.8
		1	*Triplasta coxalis*	1	2.0
	Palaeosepsis sp.	16	*Kleidotoma nigra*	4	25
Rural	*Archisepsis scabra*	15	*Kleidotoma* sp.	2	13.3
			Triplasta atrocoxalis	2	13.3
	Palaeosepsis sp.	90	*Kleidotoma nigra*	8	8.8
	Sarcophagula occidua	15	*Spalangia cameroni*	3	20.0
Urban	*Brontaea quadristigma*	6	*Trichopria* sp.	1	16.7
		45	*Trichopria* sp.	11	24.4

Additionally, *Trichopria* sp. demonstrated high parasitism efficiency in urban environments, reinforcing its potential in biological control. Overall, the study emphasizes the importance of parasitoids as regulators of dipteran populations and their relevance in integrated pest management strategies (Marchiori *et al.,* 2008b).

20. Faunistic Indices and Monthly Variation of Diptera and Parasitoid Hymenoptera Associated with Bovine Feces / 20.1. Method used (4)

The climate in Itumbiara *showed* two well-defined seasons: a humid and warm season during the summer and a dry and cooler season during the winter. Higher average temperatures were recorded in November and September, while the lowest occurred in June and July. The population dynamics of Diptera varied throughout the year. *S. occidua* showed population peaks in March, May, and September, while *Ravinia belforti* (Prado & Fonseca 1932) (Diptera: Sarcophagidae) presented peaks in July and September. Species of *Brontaea* sp. exhibited peaks mainly in December and May, whereas *Cyrtoneurina* sp. showed higher abundance in February and July. Among Sepsidae, *Palaeosepsis insularis* Williston, 1896 (Diptera: Sepsidae) was more abundant in December and January, while *Palaeosepsis pusio* Schiner, 1868 (Diptera: Sepsidae) showed peaks in April and June.

Archisepsis scabra was less frequent, occurring mainly in March and June. The distribution of Diptera species did not show a clear predominance in any specific season, differing from patterns observed in other regions, where higher abundance is typically associated with warm and humid periods. In contrast, parasitoid species exhibited greater abundance during warm and humid months. *Spalangia drosophilae* was more abundant in December and January, while *S. endius* and *S. nigroaenea* showed population peaks in December. Other parasitoids also exhibited seasonal variation. *S. cameroni* reached its peak in January, *Trichopria* sp. showed peaks in January and August, and *Neralsia* sp. in January and July. Among Eucoilinae, species sp1 showed a peak in December, while sp2 and sp3 presented peaks in January and April, and January and July, respectively (Figure 21) (Table 26).

Table 26: This table presents the faunistic indices of Diptera and their associated parasitoids in bovine dung. It highlights species distribution, frequency, constancy, and dominance within the studied environment. The data also emphasize seasonal variation and the ecological interactions between hosts and parasitoids

Taxonomic group	Species	Constancy (A1)	Dominance (D2)
Diptera	*Archisepsis scabra*	Z	ND
	Brontaea sp1	X	ND
	Brontaea sp2	X	D
	Cyrtoneurina sp.	X	ND
	Oxysarcodexia thornax	Z	ND
	Palaeosepsis insularis	X	D
	Palaeosepsis pusio	X	D
	Ravinia belforti	X	ND
	Sarcophagula occidua	X	D
Hymenoptera	Eucoilinae sp1	Y	ND
	Eucoilinae sp2	X	D
	Eucoilinae sp3	X	ND

Taxonomic group	Species	Constancy (A1)	Dominance (D2)
	Neralsia sp.	Z	ND
	Spalangia cameroni	X	ND
	Spalangia drosophilae	X	ND
	Spalangia endius	X	ND
	Spalangia nigroaenea	X	D
	Trichopria sp.	Z	ND

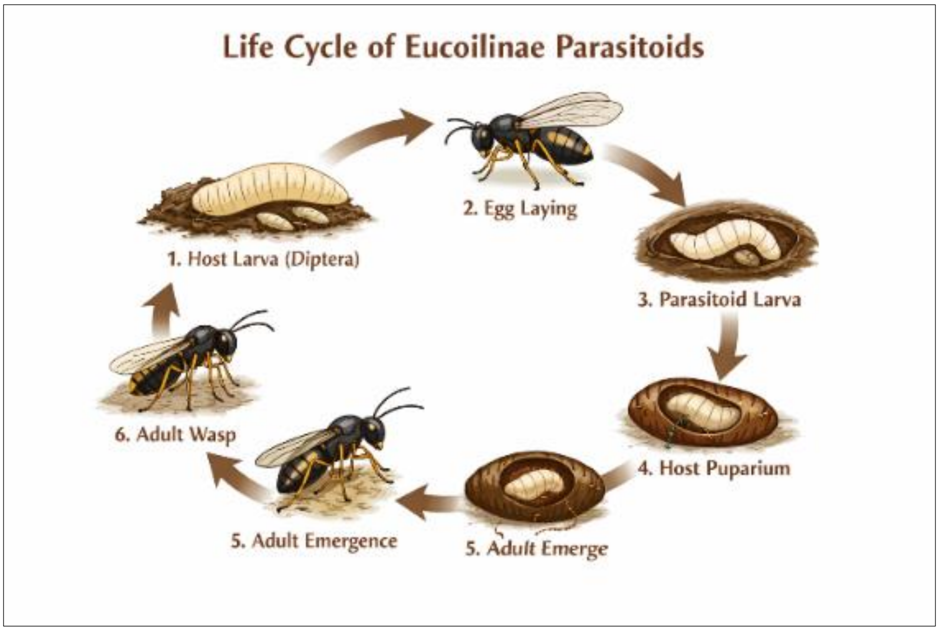

Figure 21: Life cycle of parasitoids associated with host development and pupation stages. The parasitoid–host interaction is characterized by progressive consumption of the host larva, pupation, and adult emergence

These results indicate that parasitoid populations tend to increase after the winter period, with a resumption of activity approximately three months after colder conditions. Faunistic indices demonstrated that most host and parasitoid species were classified as constant, although generally not dominant. Some species, such as *Brontaea* spp. and *P. pusio*, were also considered constant in other studies, reinforcing their ecological importance (Figure 22).

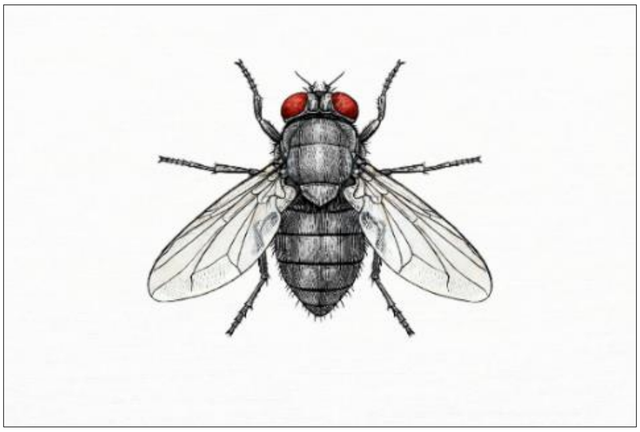

Figure 22: *Brontaea* spp. Morphological features such as wing venation, bristle distribution, and body segmentation are illustrated for taxonomic reference

However, differences were observed when compared to other regions, where some parasitoid species behaved as accidental or accessory, indicating that environmental conditions and habitat characteristics strongly influence species distribution and dominance. These findings highlight the importance of parasitoids in the ecological dynamics of Diptera associated with bovine dung and reinforce their role as natural regulators in pasture ecosystems (Marchiori and Linhares, 1999).

21. *Gnathopleura Semirufa* (Brullé, 1846), a Parasitoid of Dipterous Synanthropes in the Southern Part of Goiás, Brazil / 21.1. Method used (4)

A total of 305 pupae of *O. thornax*, 143 pupae of *P. chrysostoma*, and 182 pupae of *S. lambens* were collected. From these hosts, 75, 51, and 31 specimens of the parasitoid *G. semirufa* emerged, respectively. The parasitism rates were 24.6% for *O. thornax*, 35.7% for *P. chrysostoma*, and 17.0% for *S. lambens*. The overall parasitism rate was approximately 25.0%, indicating a relatively high level of parasitism under the conditions studied (Figure 23).

Figure 23: *Gnathopleura semirufa* associated with dipteran hosts developing in decomposing substrates. Source: **Photo 142837156, (c) D. Valencia, some rights reserved (CC BY-NC), uploaded by D. Valenci**

The Alysiinae are a large subfamily of Braconidae containing over 1,000 described species worldwide. They are koinobiont endoparasitoids of cyclorrhaphan Diptera. They larviposit or oviposit on the host, the larvae penetrate the host, and the adults emerge from the puparia. Among the hosts, *P. chrysostoma* showed the highest parasitism rate, which may be associated with seasonal factors influencing host availability and parasitoid activity. The variation in parasitism rates among host species may also be related to differences in host density, resource quality, and environmental conditions (Table 27).

Table 27: Parasitism of *Gnathopleura semirufa* in Sarcophagidae hosts (Itumbiara, GO). This table presents the parasitism rates of G. *semirufa* in different Sarcophagidae host species

Diptera (Host)	Number of pupae	Number of parasitoids	Parasitized pupae	Parasitism (%)
Oxysarcodexia thornax	305	75	75	24.6
Peckia chrysostoma	143	51	51	35.7
Sarcodexia lambens	182	31	31	17.0
Total	**630**	**157**	**157**	**25.0**

These findings confirm the association of *G. semirufa* with dipteran species of the family Sarcophagidae in Brazil. Additionally, this study represents the first record of *G. semirufa* parasitizing *O. thornax*, *P. chrysostoma*, and *S. lambens* in southern Goiás. The results reinforce the importance of parasitoids as natural enemies of synanthropic flies and highlight their potential application in biological control programs (Marchiori, 2014).

22. Hymenoptera Parasitoids of Calliphoridae of Forensic Interest: New Occurrences / 22.1. Method used (1)

A total of 595 puparia of Diptera belonging to the family Calliphoridae were collected from pig carcasses. Among these, 465 specimens belonged to the genus *Chrysomya* and 130 to *Hemilucilia segmentaria* (Fabricius, 1805) (Diptera: Calliphoridae). Three species of parasitoid Hymenoptera emerged from these puparia. *Trichopria* sp. (Diapriidae) emerged from pupae of *Chrysomya* spp., while *Spalangia* sp. and *P. vindemmiae* (Pteromalidae) emerged from pupae of *H. segmentaria* (Figure 24).

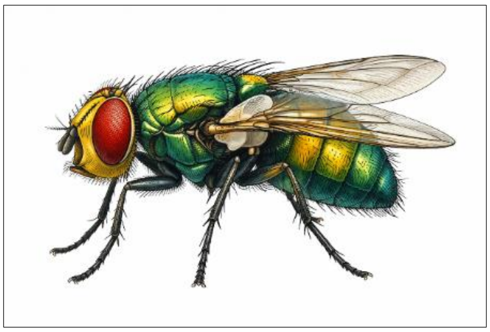

Figure 24: *Hemilucilia segmentaria*, highlighting the yellow head, red compound eyes, and metallic green–yellow body coloration. The illustration emphasizes key morphological traits, wing venation, abdominal segmentation, and bristle distribution

The parasitism rates were 2.3% for *Trichopria* sp., 0.8% for *Spalangia* sp., and 0.8% for *P. vindemmiae*. These results demonstrate the association of parasitoids with Calliphoridae foraging flies of forensic importance and highlight their role as natural enemies in decomposing environments. Previous studies have reported *Trichopria* sp. parasitizing several dipteran hosts in Brazil, including species associated with cattle dung and synanthropic environments, indicating its ecological adaptability.

Similarly, *Spalangia* spp. and *P. vindemmiae* have been widely recorded as parasitoids of dipteran pupae in different substrates, reinforcing their importance in natural biological control. This study represents the first record of *Trichopria* sp. emerging from pupae of *Chrysomya* spp. in the state of Minas Gerais, as well as the first record of parasitism of *Spalangia* sp. and *P. vindemmiae* in *H. segmentaria* in Brazil. These findings contribute to the understanding of parasitoid-host relationships in forensic entomology and highlight their potential importance in ecological and applied studies (Silva *et al.*, 2005).

23. Parasitoids of Dipterans Collected in Itumbiara, GO, and Tupaciguara, MG, Brazil / 23.1. Method used (1)

A total of 216 parasitoids were recorded in Itumbiara (GO) and 233 in Tupaciguara (MG). In Itumbiara, the most abundant species was *B. podagrica* (n = 173), followed by *N. vitripennis* (n = 34), while other species such as *Aphaereta* sp., *Trybliographa* sp., *P. vindemmiae*, and *Spalangia* sp. were recorded at lower frequencies. In Tupaciguara, *P. vindemmiae* was the dominant species (n = 192), followed by *N. vitripennis* (n = 14) and *Hemencyrtus* sp. (n = 11). The remaining species occurred at low frequencies. These results demonstrate differences in parasitoid community composition between the two locations.

In Tupaciguara, *P. vindemmiae* was the dominant species, accounting for 82.4% of the parasitoids, possibly due to its strong host-searching capacity and ecological adaptability. The parasitism rates were 0.4% for *Aphaereta* sp., 12.3% for *B. podagrica*, 2.4% for *N. vitripennis*, 0.1% for *P. vindemmiae*, 0.1% for *Spalangia* sp., and 0.1% for *Trybliographa* sp. The highest parasitism rate was observed for *B. podagrica*. In Tupaciguara, the parasitism rates were 0.6% for *B. podagrica*, 0.7% for *Hemencyrtus* sp., 0.8% for *N. vitripennis*, 0.1% for *Neralsia* sp., 11.6% for *P. vindemmiae*, and 0.3% for *S. endius*. The highest parasitism rate was observed for *P. vindemmiae* (Table 28).

Table 28: This table presents the parasitoid species collected in both locations and their occurrence. It highlights species distribution and differences between the two environments

Taxonomic group	Species	Itumbiara (GO)	Tupaciguara (MG)
Braconidae	*Aphaereta* sp.	5	0
Chalcididae	*Brachymeria podagrica*	173	10
Encyrtidae	*Hemencyrtus* sp.	0	11
Figitidae	*Neralsia* sp.	0	1
Figitidae	*Trybliographa* sp.	1	0
Pteromalidae	*Nasonia vitripennis*	34	14
	Pachycrepoideus vindemmiae	1	192
	Spalangia sp.	2	0
	Spalangia endius	0	5
Total	------------	**216**	**233**

Host preference analysis showed that, in Itumbiara, *Aphaereta* sp. preferred *P. chrysostoma*, *B. podagrica* preferred *P. chrysostoma* and *S lambens*, *N. vitripennis* preferred *C. albiceps* and *C. megacephala*, *P. vindemmiae* preferred *S. lambens*, *Spalangia* sp. preferred *M. domestica*, and *Trybliographa* sp. preferred *O. thornax* (χ^2 = 422.16; df = 40; P < 0.05) (Figure 25).

Figure 25: Family Figitidae are parasitoids of various fly larvae. For example, *Trybliographa* sp. parasitizes on *Delia radicum* (Linnaeus, 1758) (Diptera: Anthomyiidae)

A total of 1,330 dipteran pupae were recorded in Itumbiara, from which 215 were parasitized. The highest number of parasitized pupae was observed in *S. lambens* (n = 110), followed by *P. chrysostoma* (n = 84). In *C. albiceps*, 15 parasitized pupae were recorded, while *C. megacephala* and *M. domestica* presented lower values, with 3 and 2 parasitized pupae, respectively. Other species, such as *O thornax*, also showed low parasitism levels (n = 1). These results reinforce the importance of specific host species in maintaining parasitoid populations in the studied area. (χ^2 = 471.08; df = 35; P < 0.05) (Table 29).

Table 29: Number of parasitized pupae in Itumbiara. This table presents dipteran species and associated parasitoids. It highlights host–parasitoid relationships and parasitized pupae

Diptera species	Frequency	Parasitoid	Parasitized pupae
Chrysomya albiceps	93	*Nasonia vitripennis*	15
Chrysomya megacephala	163	*Brachymeria podagrica*	1
		Nasonia vitripennis	2
Musca domestica	180	*Spalangia* sp.	2
Oxysarcodexia thornax	11	*Brachymeria podagrica*	1
Peckia chrysostoma	340	*Aphaereta* sp.	3
		Brachymeria podagrica	69
		Nasonia vitripennis	12
Sarcodexia lambens	543	*Aphaereta* sp.	2
		Brachymeria podagrica	102
		Nasonia vitripennis	5
		Pachycrepoideus vindemmiae	1
Total	**1330**	**----------**	**215**

These results reinforce the importance of parasitoids as natural regulators of Diptera populations and highlight their potential application in biological control programs (Marchiori *et al.*, 2006).

24. Parasitoids of Peckia *Chrysostoma* Collected in Pupae in Bovine Kidney / 24.1. Method used (1)

A total of 942 pupae of *P. chrysostoma* were collected, from which 921 parasitoids emerged. The overall parasitism percentage was 97%, indicating a very high level of parasitism under the studied conditions. Among the parasitoids, *Aphaereta* sp. was the most abundant species, accounting for 54.7% of the parasitism (504 individuals), followed by *H. herbertii* with 23.9% (220 individuals) and *N. vitripennis* with 13.6% (125 individuals) (Figure 26).

Figure 26: Lateral view of *Peckia chrysostoma*, characterized by its robust gray body, distinct thoracic pattern, and well-developed compound eyes. biodar.unlp.edu.ar

A total of 921 parasitoids were recorded, with *Aphaereta* sp. being the most abundant species (54.7%), followed by *H. herbertii* (23.9%) and *N. vitripennis* (13.6%). Other species, including *Trichopria* sp. (4.5%) and *B. podagrica* (2.9%), were less frequent, while *G. quadridentata* (0.3%) and *P. vindemmiae* (0.1%) showed low occurrence. These results highlight the dominance of a few parasitoid species and the presence of gregarious parasitoids contributing to high parasitism levels in the studied environment. (Table 30).

Table 30: It highlights parasitism rates, species composition, and the occurrence of gregarious parasitoids. The data also emphasize the high parasitism levels and the ecological importance of these parasitoids in regulating dipteran populations

Parasitoid species	Number of parasitoids	Parasitism (%)
Aphaereta sp.	504	54.7
Brachymeria podagrica	27	2.9
Gnathopleura quadridentata	3	0.3
Hemencyrtus herbertii	220	23.9
Nasonia vitripennis	125	13.6
Pachycrepoideus vindemmiae	1	0.1
Trichopria sp.	41	4.5
Total	921	100

Previous studies have reported similar patterns, with high parasitism rates associated with these parasitoid species in different substrates, including human feces, liver, fish, and bovine kidney. These results expand the knowledge of parasitoid-host relationships involving *Peckia chrysostoma* and reinforce the importance of parasitoids as natural enemies of synanthropic flies (Figure 27) (Bonani *et al.*, 2006).

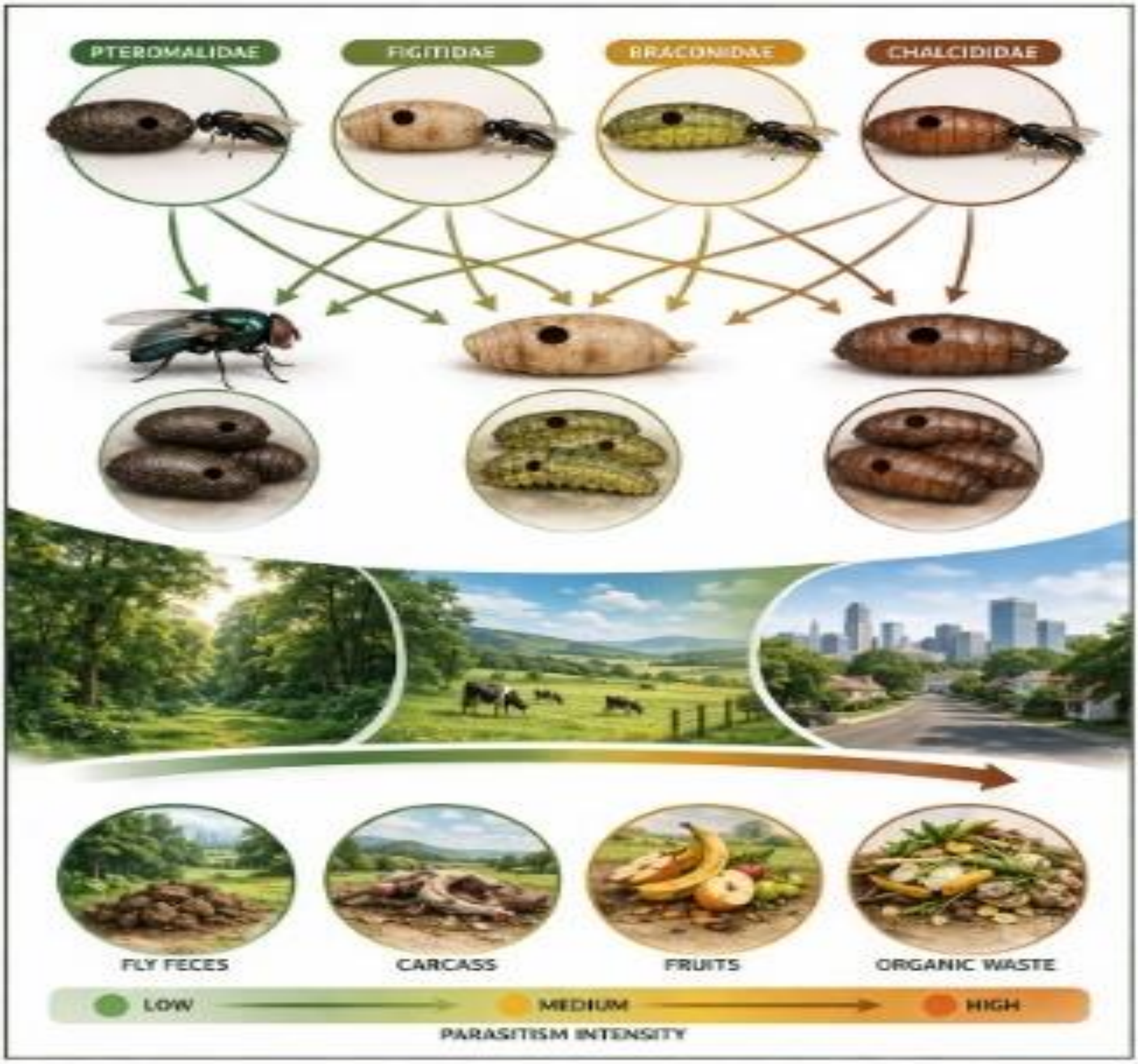

Figure 27: Parasitoid–host interactions associated with Diptera developing in decomposing organic substrates. The figure illustrates relationships between parasitoids, their hosts, substrates, and environmental conditions across forests, rural, and urban ecosystems

5.0. DISCUSSION GENERAL

The results obtained from the different studies demonstrate that parasitoids play a fundamental role in regulating populations of synanthropic Diptera across a wide range of substrates and environments. Among the parasitoids, *P vindemmiae*, *N. vitripennis*, and species of the genus *Spalangia* were consistently the most frequent. Their occurrence in multiple substrates and host species indicates a high degree of ecological plasticity. These species are known for their generalist behavior, which allows them to exploit a wide variety of hosts and environments, increasing their effectiveness as natural enemies (Figure 28) (Marchiori, 2021a; Marchiori, 2021b; Marchiori, 2022).

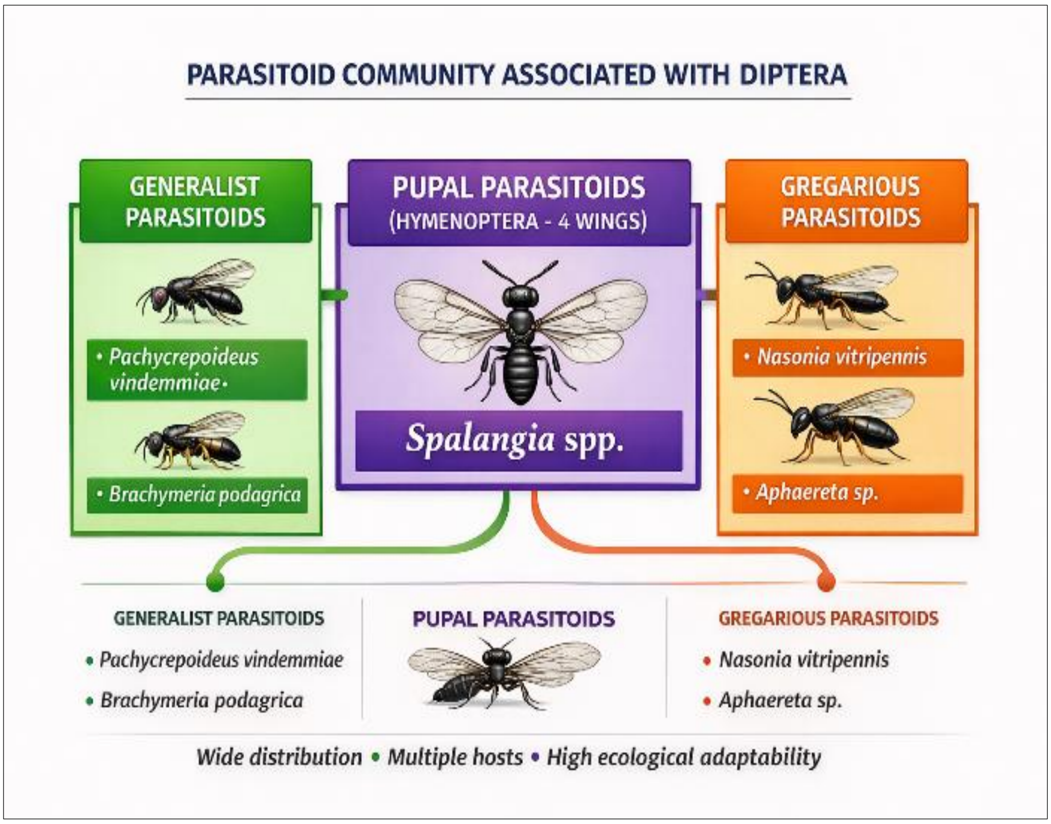

Figure 28: Highlighting generalist, gregarious, and pupal parasitoids across different substrates. Demonstrating their wide distribution, host diversity, and ecological adaptability

In contrast, some parasitoids, such as *Aphaereta* sp. and *B. podagrica,* showed intermediate occurrence but were strongly associated with substrates rich in organic matter. The presence of gregarious parasitoids, particularly *Aphaereta* sp. and *N. vitripennis*, was associated with higher parasitoid numbers, since multiple individuals can emerge from a single host (Marchiori *et al.,* 2008a; Marchiori *et al.,* 2008b; Marchiori, 2021a; Cingolani *et al.,* 2025).

The host species also played a crucial role in determining parasitism patterns. Species such as *M. domestica*, *C. albiceps*, and *P. chrysostoma* were the most frequently parasitized, likely due to their high abundance and wide distribution in decomposing organic substrates. These species are commonly associated with human activities and therefore represent important targets for biological control (Figure 29) (Marchiori, 2021a; Marchiori, 2021b).

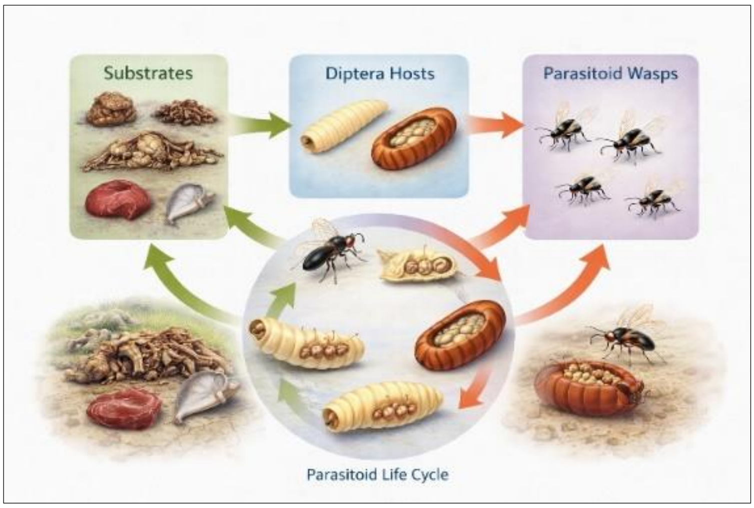

Figure 29: Ecological interaction between substrates, Diptera hosts, and parasitoid species. Demonstrating the relationships influencing host availability and parasitoid activity

Substrate type was another key factor influencing parasitoid occurrence and parasitism rates. Organic substrates such as feces, carcasses, fruits, and animal viscera supported a higher diversity of parasitoids, as they provide suitable conditions for the development of Diptera larvae. Higher parasitism rates observed in these substrates are likely related to increased host density and resource availability (Marchiori, 2022; Peralta-Aragón *et al.,* 2025; Rocha *et al.,* 2025; Gudin *et al.*, 2026).

Environmental conditions, particularly humidity, also influenced parasitoid activity. Studies comparing environments such as forests and pastures indicated higher abundance and diversity of parasitoids under more humid conditions. This suggests that microclimatic factors may directly affect both host availability and parasitoid efficiency (Figure 30) (Marchiori, 2019a; Marchiori, 2019b; Rocha *et al.,* 2025; Gudin *et al.*, 2026; Hopper and Leung, 2026).

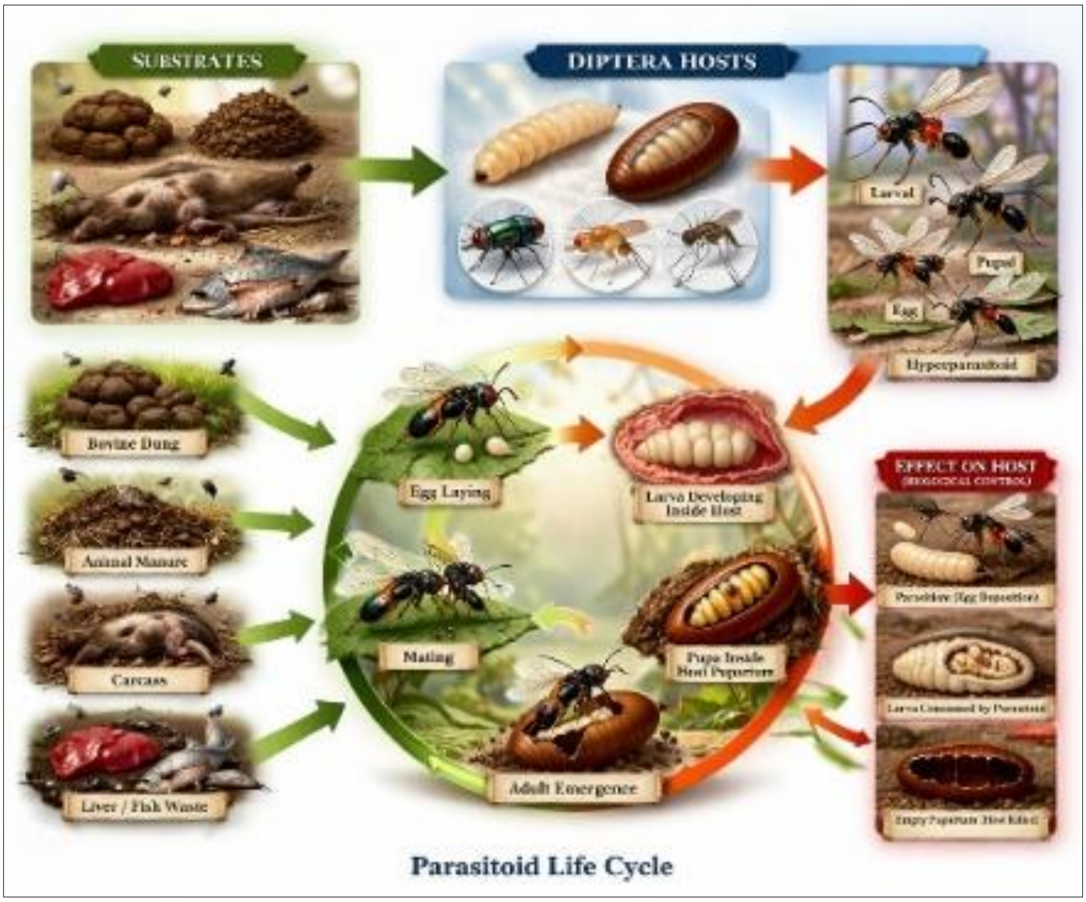

Figure 30: Life cycle of a parasitoid showing the stages of development: egg, larva, pupa, and adult. Illustrating the progression of the parasitoid within the host. Highlighting the complete biological cycle and host interaction

Parasitism rates varied widely among studies, ranging from very low values (below 1%) to extremely high levels (up to 97%). This variation can be explained by differences in host density, substrate type, parasitoid behavior (solitary or gregarious), and environmental conditions. The wide host range observed for several parasitoid species, especially *P vindemmiae* and *Spalangia* spp., highlights their potential for use in biological control programs. Their ability to persist in different environments and exploit multiple hosts makes them promising agents for reducing populations of synanthropic flies of medical and veterinary importance (Marchiori *et al.,* 2000a; Marchiori *et al.,* 2000b; Marchiori *et al.,* 2000c; Marchiori *et al.,* 2000d; Marchiori, 2022; Gudin *et al.,* 2026).

Overall, the integration of results from multiple studies provides strong evidence that parasitoids are key components of ecological systems involving decomposing organic matter. Their role as natural enemies reinforces their importance in maintaining ecological balance and supports their application in sustainable pest management strategies (Marchiori *et al.,*2003a; Marchiori *et al.,* 2003b; Marchiori, 2021a; Marchiori, 2021b) (Figure 31).

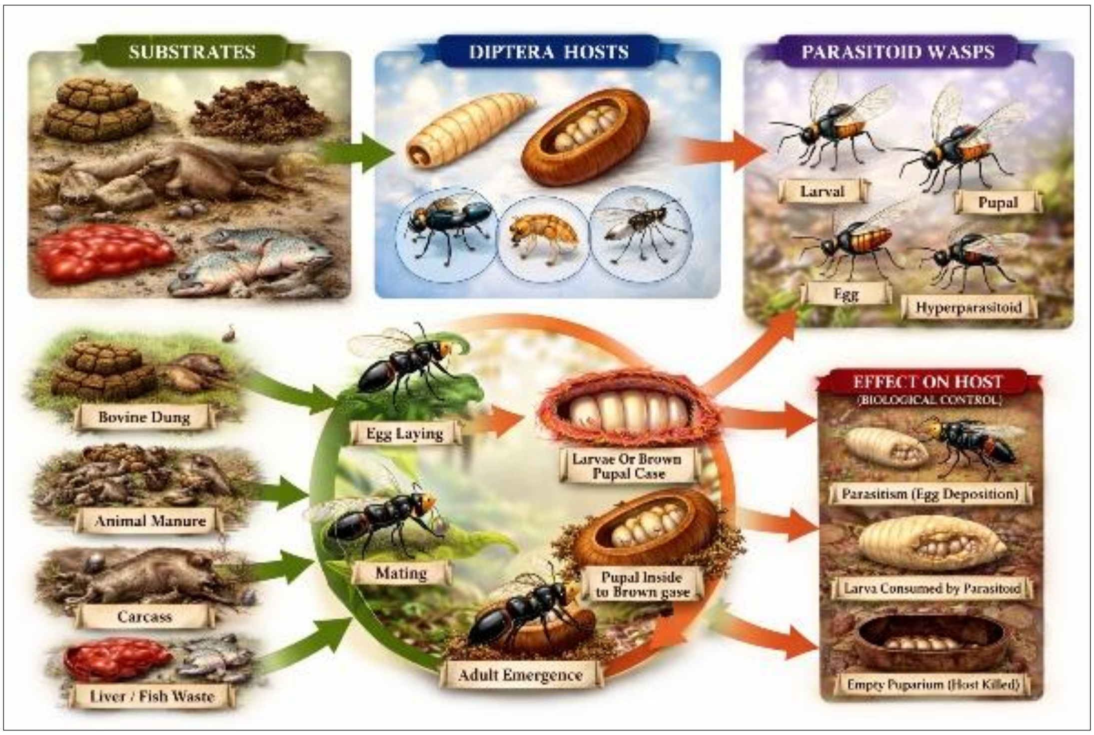

Figure 31: Integrated representation of the ecological relationships among substrates, Diptera hosts, and parasitoid species, including the parasitoid life cycle. Illustrating host colonization, parasitoid development, and interactions across different organic substrates

5.0. CONCLUSION

The results demonstrate that parasitoid communities associated with dipteran pupae in bovine dung vary significantly among forest, rural, and urban environments. Differences in species composition, abundance, and parasitism rates reflect the influence of environmental conditions and host availability. The predominance of *P. vindemmiae* highlights its ecological importance as a natural enemy of dung-breeding Diptera. Additionally, the higher parasitism rates observed in urban areas suggest that host density may enhance parasitoid efficiency in these environments. Overall, the study emphasizes the role of parasitoids in the natural regulation of dipteran populations and reinforces their potential application in biological control programs. These findings contribute to a better understanding of parasitoid distribution and their interactions with hosts in different habitats. Furthermore, the results indicate that habitat heterogeneity plays a key role in shaping parasitoid communities, suggesting that conservation of diverse environments may enhance the effectiveness of natural biological control agents. Future studies should focus on long-term monitoring and ecological interactions to better understand parasitoid dynamics and improve their application in integrated pest management strategies.

REFERENCES

- Bonani, J. P., Silva, C. G., Marchiori, C. H., & Torres, L. C. (2006). Parasitoids of *Peckia chrysostoma* (Wiedemann, 1830) (Diptera: Sarcophagidae) collected in pupae in bovine kidney. *Science and Agrotechnology*, *30*(2), 355–357.
- Cingolani, M. F. *et al.* (2025). Dipteran parasitoids as biocontrol agents. *BioControl, 70*, 285–300.
- Gudin, F.M. *et al.* (2026). Parasitoids, predators, or scavengers? On the nature of flesh fly (Diptera: Sarcophagidae: Sarcophaginae) interactions with eusocial wasps (Hymenoptera: Vespidae) in light of new findings in Brazil. *Insectes Sociaux,* 2026.
- Guimarães, A. *et al.* (2026). A trophic bridge for bioplastic pollution: transstadial retention and systemic toxicity of polylactic acid microplastics from necrophagous flies (*Chrysomya megacephala*) to secondary consumer beetles (*Tribolium astaneum*). *Environmental Science Processes & Impacts, 8,* 431-456.
- Hopper, K. R., & Leung, K. (2026). The genetics and mechanisms of parasitoid host specificity. *Current Opinion in Insect Science*, 10152.
- Huang, X. *et al.* (2026). The phylogeny and evolution of blow flies (Diptera: Calliphoridae) from the perspective of mitogenomics. BMC *Genomics 27*, 180.
- Jaume-Schinkela, S., & Menguala, X. (2022). New geographic distribution of *Chrysomya megacephala*, the Oriental latrine blow fly (Diptera: Calliphoridae), in Mexico using citizen science and social media. *Mexican Journal of Biodiversity, 93,* e934166.
- Keith, R., & Hopper, K. L. (2026). The genetics and mechanisms of parasitoid host specificity. *Current Opinion in Insect Science*, 101520.

- Krčmar, S. *et al.* (2026). Dataset on the fauna and biology of flesh flies (Diptera: Sarcophagidae) in the region of European Russia. *Frontiers in Insect Science, 6,* 1670763.
- Marchiori, C. H. (2000d). Parasitoids of *Sarcophagula occidua* (Diptera: Sarcophagidae) collected in cattle dung in Goiás. *Tropical Agricultural Research, 30*(1), 17–21.
- Marchiori, C. H. (2004b). *Nasonia vitripennis* (Walker) (Hymenoptera: Pteromalidae) parasitoid of muscoid Diptera collected in Itumbiara, Goiás. *Brazilian Archives of Veterinary Medicine and Animal Science, 56*(3), 422–424.
- Marchiori, C. H. (2008a). Hosts of *Triplasta atrocoxalis* (Ashmead) (Hymenoptera: Figitidae: Eucoilinae) collected in bovine and buffalo feces in Brazil. *Brazilian Archives of Veterinary Medicine and Animal Science*, *60*(3), 775–777.
- Marchiori, C. H. (2009). Hosts of the parasitoid *Paraganaspis egeria* Díaz, Gallardo & Walsh (Hymenoptera: Figitidae: Eucoilinae) collected in bovine and buffalo feces in the south of the state of Goiás. *Science and Agrotechnology, 33*, 1898-1900.
- Marchiori, C. H. (2014). *Gnathopleura semirufa* (Brullé, 1846) parasitoid of dipterous synanthropic in the southern part of Goiás, Brazil. *Annals of West University of Timişoara. Biology Series*, *17*(1), 9–12.
- Marchiori, C. H. (2019a). *Brachymeria podagrica* (Hymenoptera: Chalcididae) (Fabricius) collected in Brazil. *Qeios*, *528197*, 1–5.
- Marchiori, C. H. (2019b). Parasitoids of fruit flies collected in Brazil. *Qeios*, *832451*, 1–10.
- Marchiori, C. H. (2019c). Biodiversity of parasitoids (Hymenoptera: Figitidae: Eucoilinae) collected in Goiás, Brazil. *Qeios*, *583899*, 1–4.
- Marchiori, C. H. (2021). *Tachinobia* sp. (Hymenoptera: Eulophidae) as parasitoid of *Peckia (Sarcodexia) lambens* (Wiedemann, 1830) (Diptera: Sarcophagidae). *Open Access Research Journal of Life Sciences*, *2*(1), 023–027.
- Marchiori, C. H. (2022). Assessment of conceptual and taxonomic aspects of Scelionidae. *Open Access Research Journal of Science and Technology, 4*(1), 046–057.
- Marchiori, C. H., & Linhares, A. X. (1999). Faunistic indices and monthly variation of muscoid Diptera and parasitoid Hymenoptera associated with bovine feces. *Brazilian Society of Ecology, 299*, 1–8.
- Marchiori, C. H., Barbaresco, L. F., & Ferreira, M. E. (2008b). Parasitoids of Diptera collected in forest, rural, and urban areas in Monte Alegre, MG. *Brazilian Archives of Veterinary Medicine and Animal Science, 60*(6), 1570–1572.
- Marchiori, C. H., Barbaresco, L. F., & Miranda, M. F. (2007b). Parasitoids of dipterans collected in a slaughterhouse in Tupaciguara, Minas Gerais, Brazil. *Semina: Ciências Agrárias*, *28*(4), 695–700.
- Marchiori, C. H., Bessa, L. A., & Ribeiro, A. L. (2010). *Spalangia drosophilae* Ashmead (Hymenoptera: Pteromalidae) collected in different hosts and substrates in the south of Goiás. *Biosphere Encyclopedia*, *6*(9), 1–6.
- Marchiori, C. H., Leles, A. S., Barbaresco, L. F., & Ferreira, M. M. (2006). Parasitoids of dipterans collected in Itumbiara, GO, and Tupaciguara, MG, Brazil. *Archives of the Biological Institute*, *73*(3), 371–374.
- Marchiori, C. H., Leles, A. S., Carvalho, S. A., & Rodrigues, R. F. (2007a). Parasitoids of muscoid Diptera collected at the Alvorada slaughterhouse in Itumbiara, southern Goiás, Brazil. *Brazilian Journal of Veterinary Parasitology, 16*(4), 235–237.
- Marchiori, C. H., Oliveira, A. M. S., Martins, F. F., Bossi, F. S., & Oliveira, A. T. (2004a). Occurrence of fruit flies (Diptera: Tephritidae and Lonchaeidae) and their parasitoids in Itumbiara, GO. *Science and Agrotechnology*, *28*(6).
- Marchiori, C. H., Oliveira, A. T., & Linhares, A. X. (2000a). *Trichopria* sp. (Hymenoptera: Diapriidae) parasitoids of Diptera Muscoidea. *Archives of the Biological Institute*, *67*(1), 131–133.
- Marchiori, C. H., Oliveira, A. T., & Linhares, A. X. (2001). Species of *Spalangia* (Hymenoptera: Pteromalidae) as parasitoids of muscoid dipterous insects in cattle feces in Goiás State, Brazil. *Brazilian Archives of Medicine and Animal Science, 3*, *45*(3), 245–249.
- Marchiori, C. H., Pereira, L. A., & Filho, O. M. S. (2002a). Finding of the parasite *Hemencyrtus herbertii* (Hymenoptera: Encyrtidae) on Musca domestica (Diptera: Muscidae) in Brazil. *Public Health Journal*, *36*(2), 248–249.
- Marchiori, C. H., Pereira, L. A., & Silva Filho, O. M. (2002b). Parasitoids of *Oxysarcodexia thornax* (Walker, 1849) (Diptera: Sarcophagidae) collected in the state of Goiás, Brazil. *Journal of Tropical Pathology*, *31*(1), 134–13.
- Marchiori, C. H., Pereira, L. A., Silva Filho, O. M., & Ribeiro, L. C. S. (2003a). *Pachycrepoideus vindemmiae* (Hymenoptera: Pteromalidae) as parasitoid of Diptera in Brazil. *Science and Agrotechnology*, *27*(5), 1058–1061.
- Marchiori, C. H., Silva Filho, O. M., Borges, M. P., & Alvarenga, V. A. (2007c). Parasitoids of dipterans collected using pitfall traps in Itumbiara, Goiás. *Biotemas, 20*(1), 115–118.
- Marchiori, C. H., Silva Filho, O. M., Borges, M. P., & Moraes, P. C. (2000b). *Spalangia* spp. (Hymenoptera: Pteromalidae) as parasitoids of Diptera in cattle dung in southern Goiás, Brazil. *Brazilian Archives of Veterinary Medicine and Animal Science*, *52*(4), 1–4.
- Marchiori, C. H., Silva Filho, O. M., Borges, M. P., Moraes, P. C., & Arantes, S. B. (2003b). Parasitoides de *Musca domestica* L. (Diptera:

Muscidae) in Itumbiara, Goiás, Brasil. *Journal of Tropical Pathology*, *32*(2), 263–266.

- Marchiori, C. H., Silva, C. G., Caldas, E. R., Vieira, C. I. S., Almeida, K. G. S., Teixeira, F. F., & Linhares, A. X. (2000c). Arthropods associated with pig carcasses in Itumbiara, south of Goiás. *Archives of the Biological Institute*, *67*(2), 167–170.
- Österman, E.M., Hopkins, T. & Sääksjärvi, I. E. (2026). Local species richness of parasitoid wasps (Ichneumonidae: Pimplinae) in Afrotropical Forest: Conservation perspectives. *Insect Conservation and Diversity, 19*(1), 198–210.
- Peralta-Aragón, I., Salazar-Mendoza, P., Penteado-Dias, A. M., & Romero-Rivas, L. C. (2025). Fruit flies (Diptera: Tephritidae) and their parasitoids (Hymenoptera) in host plants along two altitudinal gradients in an Andean Forest of Peru. *Neotropical Entomology*, *54*, 1-12.
- Rocha, L. L. G. O. *et al.* (2025). Fruit flies (Diptera: Tephritidae) and their parasitoids associated with a commercial acerola orchard in Parnaíba River Valley, Brazil. *Neotropical Entomology, 54*, 122.
- Schuster, R. K., & Sivakumar, S. (2024). Development and competition of three parasitoid wasps, *Brachymeria podagrica*, *Dirhinus himalayanus*, and *Nasonia vitripennis*, in their host, *Sarcophaga dux*, in single and mixed conditions. infections. *Pathogens, 13*(7), 572.
- Silva, C. G., Marchiori, C. H., Fonseca, A. R., & Torres, L. C. (2003). Hymenopterous parasitoids of *Anastrepha* spp. larvae in star fruit (*Averrhoa carambola*) in Divinopolis, Minas Gerais, Brazil. *Science and Agrotechnology, 27*(6), 1264–1267.
- Silva, C. G., Silva, P. H., Souza, B., & Marchiori, C. H. (2005). Hymenoptera parasitoids of calliphorids of forensic interest: new occurrences. *Archives of the Biological Institute, 72*(3), 383-385.
- Teng, Z. *et al.* (2026). Direct artificial selection for longevity in the parasitic wasp *Pachycrepoideus vindemmiae* (Hymenoptera: Pteromalidae) enhances lifespan and fitness traits as a biological control agent. *Journal of Economic Entomology*, toag020.
- Zhang, P. C. *et al.* (2026). The jewel wasp *Nasonia vitripennis* utilizes two single-copy, protamine-like sperm nuclear basic proteins G3. *Bethesda*, jkag066.