OPEN ACCESS

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.v06i04.004

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Comparative Ecology of Parasitoids in Dung, Carrion, Fruit, and Trap-Based Systems in Brazil

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Abstract: Parasitoids are important natural enemies of Diptera and other insects associated with decomposing organic matter, animal feces, carcasses, fruits, and synanthropic environments. This study synthesized experimental data from field and laboratory studies conducted in Brazil, especially in Goiás and Minas Gerais, focusing on parasitoid–host interactions, substrate use, sampling methods, and parasitism patterns. The reviewed studies included cattle dung, buffalo dung, animal carcasses, bovine liver, bovine kidney, fruit substrates, Malaise traps, yellow pan traps, Scarabaeidae succession in cattle dung, and Coleoptera extraction using Berlese funnels. The compiled data were analyzed to evaluate parasitoid diversity, host associations, abundance patterns, habitat influence, trap efficiency, and temporal variation. Complementary chi-square analyses showed significant differences in parasitoid abundance, host abundance, substrate use, trap type, host–parasitoid associations, and seasonal occurrence. The results indicated that parasitoid communities were not randomly distributed and were strongly influenced by host availability, organic substrate, habitat conditions, and sampling method. Families such as Braconidae, Chalcididae, Diapriidae, Encyrtidae, Figitidae, and Pteromalidae were frequently recorded, including species with potential relevance for biological control of synanthropic, frugivorous, and medically or veterinary important flies. This synthesis highlights the ecological importance of parasitoids in decomposing substrates and reinforces the value of integrated statistical analyses for understanding host–parasitoid relationships in Brazilian environments.

Keywords: Biological Control, Chi-Square Analysis, Coleoptera, Decomposing, Diptera, Hymenoptera, Parasitoids.

RESEARCH PAPER

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How to cite this paper:
Carlos Henrique Marchiori & Klebert de Paula Malheiros (2026). Comparative Ecology of Parasitoids in Dung, Carrion, Fruit, and Trap-Based Systems in Brazil. *Middle East Res J Biological Sci, 6*(4): 314-362.

Article History:
| Submit: 22.06.2026 |
| Accepted: 25.07.2026 |
| Published: 28.07.2026 |

1.0. INTRODUCTION

Parasitoids are important natural enemies of Diptera and other insects associated with decomposing organic matter, animal feces, carcasses, fruits, and synanthropic environments. These insects play an essential ecological role in regulating populations of flies of medical, veterinary, forensic, and agricultural importance. In Brazil, several studies have reported parasitoids developing in the pupae of muscoid Diptera, frugivorous flies, and other insects associated with cattle dung, buffalo dung, animal carcasses, bovine liver, bovine kidney, fruit substrates, pasture areas, forest fragments, corrals, urban environments, and various types of traps (Marchiori, 2021; Marchiori and Malheiros, 2026; Marchiori and Malheiros, 2026a; Marchiori and Malheiros, 2026b).

The interaction between parasitoids and hosts is influenced by substrate type, host availability, habitat structure, seasonality, climatic conditions, and sampling method. Organic substrates such as feces, carcasses, and decomposing animal tissues provide suitable resources for Diptera development and, consequently, attract parasitoids that use these immature stages as hosts. In addition, traps such as Malaise traps and yellow pan traps allow the evaluation of parasitoid diversity in different environments, while methods such as Berlese funnels contribute to the recovery of Coleoptera and other arthropods associated with decomposing substrates (Marchiori, 2021; Marchiori and Malheiros, 2026; Marchiori and Malheiros, 2026a; Marchiori and Malheiros, 2026b).

Although many studies have described parasitoid occurrence in Brazil, their results are often dispersed in separate publications. Therefore, an integrated synthesis is important to organize information on parasitoid diversity, host associations, substrates, habitats, parasitism rates, and ecological patterns. The use of complementary statistical analyses, such as chi-square tests, also helps to evaluate whether differences in abundance, parasitism, host use, habitat distribution, trap efficiency, and seasonal occurrence are random or associated with biological and environmental factors (Marchiori, 2021; Marchiori and Malheiros, 2026; Marchiori and Malheiros, 2026a; Marchiori and Malheiros, 2026b).

The objective of this study was to synthesize experimental information on parasitoids, Diptera, Coleoptera, and associated arthropods collected in different substrates and environments in Brazil, with emphasis on studies conducted in Goiás and Minas Gerais. Specifically, this study aimed to: evaluate parasitoid diversity; summarize host–parasitoid associations; compare substrates and sampling methods; analyze parasitism rates; identify ecological patterns related to habitat, seasonality, and substrate use; and apply chi-square analyses to support the interpretation of quantitative data reported in the reviewed studies.

2.0. MATERIALS AND METHODS

2.0.1. General Approach

This study was based on an integrative review of experimental studies involving parasitoids associated with immature stages of Diptera in different Brazilian environments, with emphasis on studies conducted in Goiás and Minas Gerais. The reviewed investigations included field and laboratory procedures designed to sample dipteran hosts and their parasitoids in natural, rural, synanthropic, agricultural, and decomposing organic substrates. The reviewed studies also included investigations with frugivorous flies. In these cases, fruits were collected in the field and maintained in laboratory containers until larvae completed development and pupated. The recovered pupae were individualized and monitored for the emergence of adult flies or parasitoids.

The studies included in this synthesis used different sampling strategies, such as baited traps, exposed organic substrates, cattle and buffalo dung, human feces, animal carcasses, bovine liver, bovine kidney, fruit substrates, pitfall traps, Malaise traps, yellow pan traps, and laboratory emergence systems. Despite differences among experimental designs, the studies shared a common methodological structure: collection or exposure of substrates in the field, recovery of immature Diptera, isolation of pupae, laboratory monitoring until adult emergence, and identification of both dipteran hosts and parasitoids. Only studies that provided quantitative information were included in the analysis. The selected articles reported at least part of the following information: host species, parasitoid species, substrate type, sampling environment, locality, number of pupae collected, number of parasitized pupae, number of emerged parasitoids, or parasitism rate.

These data allowed comparisons of parasitoid diversity, host use, substrate association, habitat influence, sampling method efficiency, seasonal variation, and parasitism patterns. Because the reviewed articles were conducted under different environmental and methodological conditions, direct comparisons were interpreted with caution. However, the organization of the data using common variables allowed the identification of general ecological patterns among parasitoids, hosts, substrates, and environments. Thus, the synthesis combined descriptive information from the original studies with complementary statistical analyses when the available data allowed comparison among categories (Figure 1).

Figure 1: Schematic overview of parasitoids associated with Diptera and other insects in decomposing substrates in Brazil, including cattle and buffalo dung, carcasses, infested fruits, dipteran puparia, Coleoptera, Scarabaeidae succession, Malaise traps, yellow pan traps, and Berlese funnel extraction. The figure summarizes the main substrates, host systems, and sampling methods used to study parasitoid diversity and host–parasitoid interactions

2.0.2. Experimental Methods

The experimental studies included in this synthesis, baited can traps or Ferreira (1978), or black cylinder traps, used different field sampling methods to collect Diptera and their parasitoids in decomposing organic substrates and natural environments. The main substrates used were cattle dung, chicken manure, food remains, human feces, cattle kidney, fish, chicken, cattle liver, and pig carcasses. These substrates were exposed under field or semi-field conditions to attract adult Diptera, allow larval development, and obtain pupae for laboratory rearing. The reviewed studies used different field and laboratory procedures according to the substrate, insect group, and objective of each experiment. In studies involving animal carcasses, carcasses were exposed under field conditions in pasture and forest environments to allow natural colonization by insects associated with decomposition. After exposure, immature and adult arthropods were collected from the carcasses and surrounding substrate, taken to the laboratory, counted, and identified. These studies allowed the evaluation of insect occurrence during carcass decomposition and the influence of environmental conditions, such as humidity, rainfall, and habitat type, on arthropod abundance.

In studies using cattle dung and buffalo dung, fresh dung pats were exposed directly in pasture areas under field conditions. The dung was usually marked in the field to control exposure time and later collected together with part of the soil immediately below the fecal mass. In the laboratory, dipteran pupae were recovered mainly by flotation or manual separation. The pupae were counted and individualized in gelatin capsules or suitable containers until the emergence of adult Diptera or parasitoids. This procedure allowed the calculation of host abundance, number of parasitized pupae, parasitoid emergence, and parasitism rate (Figure 2).

Figure 2: Schematic representation of the main sampling methods and experimental procedures used to collect Diptera, parasitoids, Coleoptera, and associated arthropods in decomposing substrates. The figure includes baited can or black cylinder traps, carcass exposure, cattle dung, buffalo dung, Malaise traps, yellow pan traps, Scarabaeidae succession in bovine dung, and Berlese funnel extraction for small or hidden beetles from organic material. These methods were used to evaluate host abundance, parasitoid emergence, substrate use, trap efficiency, beetle succession, and arthropod recovery from field and laboratory samples

For studies involving baited traps and decomposing substrates, different organic materials were used as attractants, including bovine liver, bovine kidney, fish, human feces, chicken viscera, fruit, and food remains. These substrates were placed in traps or containers under field conditions to attract synanthropic and frugivorous Diptera. After exposure, larvae and pupae were recovered from the substrate, transferred to the laboratory, and maintained until adult emergence. Emerged flies and parasitoids were identified and quantified. Studies using Malaise traps sampled flying parasitoid Hymenoptera by intercepting insects in natural or semi-natural environments. The collected specimens were removed periodically, preserved, sorted, and identified at family or lower taxonomic levels when possible. These traps were mainly used to evaluate parasitoid family composition, abundance, and differences in capture according to sampling area and period.

Studies using yellow pan traps sampled parasitoid Hymenoptera attracted to yellow-colored containers containing water, detergent, and preservative solution. The traps were placed at ground level in pasture and forest areas and remained exposed for a defined period. The collected insects were removed, preserved in alcohol, sorted, counted, and identified. These data were used to compare parasitoid abundance between habitats, months, and trap types. In the study on Scarabaeidae succession in cattle dung, fresh bovine dung was exposed in the field for different time intervals to evaluate beetle colonization during decomposition. The dung pats were collected after predetermined exposure periods, and the Scarabaeidae specimens were separated, counted, and identified. This method allowed the evaluation of temporal succession, species abundance, and faunistic indices of dung beetles associated with bovine feces.

For studies involving Coleoptera separated using a Berlese funnel, samples of organic substrate, such as bovine feces or decomposing material, were collected in the field and taken to the laboratory. The material was placed in Berlese funnels, where heat and light drove arthropods downward into collecting containers containing a preservative solution. The Coleoptera obtained were then separated, counted, and identified by family, genus, species, or morphospecies. This method was used to improve the recovery of small or hidden beetles associated with organic substrates. In studies involving frugivorous flies, fruits were collected either directly from the field or from plants showing signs of infestation. The fruits were placed in laboratory containers containing a layer of sterilized sand or another suitable pupation substrate. The material was monitored until larvae left the fruits and pupated in the substrate. The pupae were then removed, counted, individualized, and maintained under laboratory conditions until the emergence of adult flies or parasitoids. After emergence, adult flies were identified mainly as representatives of Tephritidae, Lonchaeidae, or Drosophilidae, depending on the original study.

In the reviewed studies, dipteran hosts were obtained from different organic substrates exposed or collected under field conditions. These substrates included animal feces, decomposing carcasses, bovine liver, bovine kidney, fruit, and other organic materials attractive to synanthropic and frugivorous Diptera. In several studies, traps or substrates were placed in rural, pasture, forest, urban, or agricultural environments for predetermined exposure periods. After field exposure, the substrates were taken to the laboratory or processed in the field to recover dipteran larvae and pupae. Pupae were usually separated by flotation, sieving, or manual sorting, depending on the substrate and the methodology of each study. The recovered pupae were individualized in containers or gelatin capsules and maintained under laboratory conditions until the emergence of adult flies or parasitoids.

Parasitoids that emerged from the same pupal material were also counted and identified. These data were used to determine host–parasitoid associations and parasitism rates in frugivorous fly systems. The inclusion of fruit-based studies allowed comparison between parasitoids associated with decomposing animal substrates and those associated with frugivorous Diptera. After collection and emergence, all insects were quantified and identified using taxonomic keys or specialist confirmation, according to each original study. The following variables were compiled when available: locality, habitat, substrate type, trap type, host species, parasitoid species, number of pupae, number of parasitized pupae, number of emerged parasitoids, number of Coleoptera, frequency, and parasitism rate. Parasitism rate was calculated as the number of parasitized pupae divided by the total number of pupae, multiplied by 100.

2.0.3. Statistical Analyses

When quantitative data were available, complementary chi-square analyses were performed to compare abundance among taxa, habitats, substrates, trap types, hosts, months, and exposure periods. These analyses were applied only when the data allowed categorical comparison. When the original articles reported ANOVA or chi-square results, those values were retained and interpreted alongside the complementary analyses. Statistical significance was considered at $p < 0.05$.

2.0.4. Faunistic Indices and Data Analysis

When available in the original studies, faunistic indices were compiled and standardized to compare the ecological importance of host and parasitoid taxa among samples. The main indices considered were constancy, dominance, frequency, and abundance:

1. Constancy was expressed as C, indicating the occurrence of a taxon across sampling periods. Taxa were classified as X when present in more than 50% of the samplings, Y when present in 25% to 50% of the samplings, and Z when present in less than 25% of the samplings.
2. Dominance was expressed as D. Taxa were classified as D when dominant and ND when non-dominant.
3. Frequency was expressed as F and classified as lf for little frequent, f for frequent, and vf for very frequent.
4. Abundance was expressed as AB and classified as r for rare, d for disperse, c for common, a for abundant, va for very abundant, and sa for super-abundant. These indices were used only when reported or when the available data allowed consistent interpretation. Together with parasitism rates and chi-square analyses, they helped characterize the relative importance, distribution, and ecological representativeness of parasitoids and their dipteran hosts in different substrates, habitats, and sampling systems.

2.0.5. Note

Figures include both photographic records and schematic illustrations. Wing venation was omitted or simplified in schematic figures for clarity and does not represent diagnostic morphological variation among parasitoid taxa (Table 1).

Table 1: Taxonomic table of the main insect taxa cited in the article

Taxonomic group	Authority	Order	Family	First citation in the text	Subsequent citation
Aganaspis pelleranoi	(Brèthes, 1924)	Hymenoptera	Figitidae	*Aganaspis pelleranoi* (Brèthes, 1924) (Hymenoptera: Figitidae)	*A. pelleranoi*
Anastrepha fraterculus	(Wiedemann, 1830)	Diptera	Tephritidae	*Anastrepha fraterculus* (Wiedemann, 1830) (Diptera: Tephritidae)	*A. fraterculus*
Anastrepha sp.	-	Diptera	Tephritidae	*Anastrepha* sp. (Diptera: Tephritidae)	*Anastrepha* sp.
Aphaereta sp.	Förster, 1863	Hymenoptera	Braconidae	*Aphaereta* (Hymenoptera: Braconidae)	*Aphaereta* sp.
Archisepsis scabra	(Loew, 1861)	Diptera	Sepsidae	*Archisepsis scabra* (Loew, 1861) (Diptera: Sepsidae)	*A. scabra*
Brachymeria podagrica	(Fabricius, 1787)	Hymenoptera	Chalcididae	*Brachymeria podagrica* (Fabricius, 1787) (Hymenoptera: Chalcididae)	*B. podagrica*
Brontaea debilis	(Williston, 1896)	Diptera	Muscidae	*Brontaea debilis* (Williston, 1896) (Diptera: Muscidae)	*B. debilis*
Brontaea quadristigma	(Thomson, 1869)	Diptera	Muscidae	*Brontaea quadristigma* (Thomson, 1869) (Diptera: Muscidae)	*B. quadristigma*
Chrysomya albiceps	(Wiedemann, 1819)	Diptera	Calliphoridae	*Chrysomya albiceps* (Wiedemann, 1819) (Diptera: Calliphoridae)	*C. albiceps*
Chrysomya megacephala	(Fabricius, 1794)	Diptera	Calliphoridae	*Chrysomya megacephala* (Fabricius, 1794) (Diptera: Calliphoridae)	*C. megacephala*
Cyrtoneurina pararescita	Couri, 1995	Diptera	Muscidae	*Cyrtoneurina pararescita* Couri, 1995 (Diptera: Muscidae)	*C. pararescita*
Dicerataspis grenadensis	Ashmead, 1895	Hymenoptera	Figitidae	*Dicerataspis grenadensis* Ashmead, 1895 (Hymenoptera: Figitidae),	*D. grenadensis*
Fannia pusio	(Wiedemann, 1830)	Diptera	Fanniidae	*Fannia pusio* (Wiedemann, 1830) (Diptera: Fanniidae)	*F. pusio*
Gnathopleura quadridentata	Wharton, 1986	Hymenoptera	Braconidae	*Gnathopleura quadridentata* Wharton, 1986 (Hymenoptera: Braconidae)	*G. quadridentata*
Hemencyrtus herbertii	Ashmead, 1900	Hymenoptera	Encyrtidae	*Hemencyrtus herbertii* Ashmead, 1900 (Hymenoptera: Encyrtidae)	*H. herbertii*
Kleidotoma nigra	(Hartig, 1840)	Hymenoptera	Figitidae	*Kleidotoma nigra* (Hartig, 1840) (Hymenoptera: Figitidae)	*K. nigra*

Taxonomic group	Authority	Order	Family	First citation in the text	Subsequent citation
Megaselia scalaris	(Loew, 1866)	Diptera	Phoridae	*Megaselia scalaris* (Loew, 1866) (Diptera: Phoridae)	*M. scalaris*
Musca domestica	Linnaeus, 1758	Diptera	Muscidae	*Musca domestica* Linnaeus, 1758 (Diptera: Muscidae)	*M. domestica*
Muscidifurax raptor	Girault & Sanders, 1910	Hymenoptera	Pteromalidae	*Muscidifurax raptor* Girault & Sanders, 1910 (Hymenoptera: Pteromalidae)	*M. raptor*
Nasonia vitripennis	(Walker, 1836)	Hymenoptera	Pteromalidae	*Nasonia vitripennis* (Walker, 1836) (Hymenoptera: Pteromalidae)	*N. vitripennis*
Oxysarcodexia thornax	(Walker, 1849)	Diptera	Sarcophagidae	*Oxysarcodexia thornax* (Walker, 1849) (Diptera: Sarcophagidae)	*O. thornax*
Pachycrepoideus vindemmiae	(Rondani, 1875)	Hymenoptera	Pteromalidae	*Pachycrepoideus vindemmiae* (Rondani, 1875) (Hymenoptera: Pteromalidae)	*P. vindemmiae*
Palaeosepsis spp.	Duda, 1926	Diptera	Sepsidae	*Palaeosepsis* spp. (Diptera: Sepsidae)	*Palaeosepsis* spp.
Paraganaspis egeria	Díaz, Gallardo & Walsh, 1996	Hymenoptera	Figitidae	*Paraganaspis egeria* Díaz, Gallardo & Walsh, 1996 (Hymenoptera: Figitidae)	*P. egeria*
Peckia chrysostoma	(Wiedemann, 1830)	Diptera	Sarcophagidae	*Peckia chrysostoma* (Wiedemann, 1830) (Diptera: Sarcophagidae)	*P. chrysostoma*
Ravinia belforti	(Prado & Fonseca, 1932)	Diptera	Sarcophagidae	*Ravinia belforti* (Prado & Fonseca, 1932) (Diptera: Sarcophagidae)	*R. belforti*
Sarcodexia lambens	(Wiedemann, 1830)	Diptera	Sarcophagidae	*Sarcodexia lambens* (Wiedemann, 1830) (Diptera: Sarcophagidae)	*S. lambens*
Sarcophagula occidua	(Fabricius, 1794)	Diptera	Sarcophagidae	*Sarcophagula occidua* (Fabricius, 1794) (Diptera: Sarcophagidae)	*S. occidua*
Spalangia cameroni	Perkins, 1910	Hymenoptera	Pteromalidae	*Spalangia cameroni* Perkins, 1910 (Hymenoptera: Pteromalidae)	*S. cameroni*
Spalangia drosophilae	Ashmead, 1887	Hymenoptera	Pteromalidae	*Spalangia drosophilae* Ashmead, 1887 (Hymenoptera: Pteromalidae)	*S. drosophilae*
Spalangia endius	Walker, 1839	Hymenoptera	Pteromalidae	*Spalangia endius* Walker, 1839 (Hymenoptera: Pteromalidae)	*S. endius*

Taxonomic group	Authority	Order	Family	First citation in the text	Subsequent citation
Spalangia nigra	Latreille, 1805	Hymenoptera	Pteromalidae	*Spalangia nigra* Latreille, 1805 (Hymenoptera: Pteromalidae)	*S. nigra*
Spalangia nigroaenea	Curtis, 1839	Hymenoptera	Pteromalidae	*Spalangia nigroaenea* Curtis, 1839 (Hymenoptera: Pteromalidae)	*S. nigroaenea*
Squamatoides trivittatus	Curran, 1927	Diptera	Sarcophagidae	*Squamatoides trivittatus* Curran, 1927 (Diptera: Sarcophagidae)	*S. trivittatus*
Steleucoela sp.	Kieffer, 1908	Hymenoptera	Figitidae	*Steleucoela* sp. (Hymenoptera: Figitidae)	*Steleucoela* sp.
Trichillum externepunctatum	Borre, 1886	Coleoptera	Scarabaeidae	*Trichillum externepunctatum* Borre, 1886 (Coleoptera: Scarabaeidae)	*T. externepunctatum*
Triplasta atrocoxalis	(Ashmead, 1865)	Hymenoptera	Figitidae	*Triplasta atrocoxalis* (Ashmead, 1865) (Hymenoptera: Figitidae)	*T. atrocoxalis*
Triplasta coxalis	(Ashmead, 1865)	Hymenoptera	Figitidae	*Triplasta coxalis* (Ashmead, 1865) (Hymenoptera: Figitidae)	*T. coxalis*
Trybliographa sp.	Förster, 1869	Hymenoptera	Figitidae	*Trybliographa* sp. (Hymenoptera: Figitidae)	*Trybliographa* sp.
Zaeucoila incompleta	(Kieffer, 1907)	Hymenoptera	Figitidae	*Zaeucoila incompleta* (Kieffer, 1907) (Hymenoptera: Figitidae)	*Z. incompleta*

3.0. RESULTS

The reviewed studies demonstrated a high diversity of parasitoids and associated insects collected from different substrates and environments, including bovine feces, buffalo dung, human feces, pig carcasses, bovine liver, bovine kidney, fruit substrates, pasture areas, forest areas, corrals, and traps. The main parasitoid groups recorded belonged to Hymenoptera, especially Braconidae, Chalcididae, Diapriidae, Encyrtidae, Figitidae, and Pteromalidae. These parasitoids were mainly associated with immature stages of Diptera, particularly pupae, although some studies also recorded parasitoids on larvae or in host systems involving frugivorous flies.

Overall, the results showed that parasitoid occurrence was strongly influenced by substrate type, host availability, environmental conditions, habitat structure, and sampling method. Substrates rich in decomposing organic matter, such as animal feces, carcasses, bovine liver, and bovine kidney, supported both dipteran development and parasitoid activity. In several studies, the most frequent parasitoids included *Aphaereta* sp. (Hymenoptera: Braconidae), *Brachymeria podagrica* (Fabricius, 1787) (Hymenoptera: Chalcididae), *Gnathopleura quadridentata* Wharton, 1986 (Hymenoptera: Braconidae), *Hemencyrtus herbertii*, Ashmead, 1900 (Hymenoptera: Encyrtidae), *Nasonia vitripennis* (Walker, 1836) (Hymenoptera: Pteromalidae), *Pachycrepoideus vindemmiae* (Rondani, 1875) (Hymenoptera: Pteromalidae), *Paraganaspis egeria* Diaz, Gallardo & Wash, 1996 (Hymenoptera: Figitidae), *Spalangia cameroni* Perkins, 1910 (Hymenoptera: Pteromalidae), *Spalangia drosophilae* Ashmead, 1887 (Hymenoptera: Pteromalidae), *Spalangia endius* Walker, 1839 (Hymenoptera, Pteromalidae), *Spalangia nigroaenea* Latreille, 1805 (Hymenoptera, Pteromalidae), *Triplasta atrocoxalis* (Ashmead, 1865) (Hymenoptera: Figitidae) and *Triplasta coxalis* (Ashmead, 1865) (Hymenoptera: Figitidae).

The parasitism rates varied widely among studies. Low parasitism values were recorded in some first-occurrence studies, such as *Muscidifurax raptor* Girault & Sanders, 1910 (Hymenoptera: Pteromalidae) associated with *Palaeosepsis* spp. (Diptera: Sepsidae), and *Sarcophagula occidua* Fabricius, 1794 (Diptera: Sarcophagidae), whereas higher rates were observed in systems involving *Peckia chrysostoma* (Wiedemann, 1830) (Diptera: Sarcophagidae), and *Sarcodexia lambens* (Wiedemann, 1830) (Diptera: Sarcophagidae), some parasitoid–host associations in bovine feces or organic substrates. This variation indicates that parasitoid efficiency depends not only on the presence of suitable hosts but also on host density, substrate conditions, parasitoid behavior, and environmental stability.

The integration of data from multiple studies also showed that parasitoid communities were not randomly distributed. Several chi-square analyses demonstrated significant differences in parasitoid abundance, host abundance, parasitism among hosts, host–parasitoid associations, trap efficiency, habitat distribution, monthly occurrence, and substrate use. These results reinforce the ecological complexity of parasitoid–host interactions and support the importance of parasitoids as natural enemies of synanthropic and medically important Diptera.

3.0.1. Experimental Chi-Square Analyses

In the article "Parasitoids of dipterous insects collected in Itumbiara, GO, and Tupaciguara, MG, Brazil", the overall parasitism rates did not differ significantly between localities ($\chi^2 = 0.88$; df = 1; p = 0.3476). However, parasitoid composition differed significantly between Itumbiara and Tupaciguara ($\chi^2 = 367.42$; df = 8; $p < 0.0001$). Host abundance also differed significantly in Itumbiara ($\chi^2 = 993.85$; df = 6; $p < 0.0001$) and Tupaciguara ($\chi^2 = 1301.68$; df = 7; $p < 0.0001$). When host distribution was compared between the two municipalities, the difference was also significant ($\chi^2 = 2126.75$; df = 9; $p < 0.0001$), indicating distinct host communities between localities.

In the article "Parasitoids of dipterous insects collected in buffalo dung in a rural property in Itumbiara, Goiás", host abundance differed significantly among dipteran species ($\chi^2 = 4807.62$; df = 5; $p < 0.0001$). The comparison between parasitized and non-parasitized pupae among hosts was also significant ($\chi^2 = 47.41$; df = 5; $p < 0.0001$). Parasitoid abundance differed significantly among taxa ($\chi^2 = 58.23$; df = 9; $p < 0.0001$). The original study also reported a significant host–parasitoid association ($\chi^2 = 146.12$; df = 45; $p < 0.05$), showing that parasitoids were not randomly distributed among hosts.

In the article "Families of parasitoids collected in forest and pasture areas in Itumbiara, Goiás", the total abundance of parasitoids differed significantly between forest and pasture ($\chi^2 = 172.77$; df = 1; $p < 0.0001$), with higher abundance in pasture. Parasitoid family abundance also differed significantly ($\chi^2 = 7309.88$; df = 20; $p < 0.0001$), and family distribution between forest and pasture was significant ($\chi^2 = 404.54$; df = 20; $p < 0.0001$). Monthly distribution was also significant ($\chi^2 = 824.46$; df = 11; $p < 0.0001$), indicating seasonal variation.

In the article "Parasitoids of *P. chrysostoma* collected in pupae in bovine kidney substrate", parasitoid abundance differed significantly among species ($\chi^2 = 1514.64$; df = 6; $p < 0.0001$). The result reflected the predominance of *Aphaereta* sp., *H. herbertii*, and *N. vitripennis* in the parasitoid assemblage.

In the article "Parasitism of *Anastrepha fraterculus* (Wiedemann, 1830) (Diptera: Tephritidae) by *Aganaspis pelleranoi* (Brèthes, 1924) (Hymenoptera: Figitidae) and *Dicerataspis flavipes* (Kieffer, 1909) (Hymenoptera: Figitidae)", the abundance of the two parasitoid taxa did not differ significantly ($\chi^2 = 0.11$; df = 1; p = 0.7459). This result indicates that both parasitoids contributed similarly to the parasitism observed in *Anastrepha* sp. pupae.

In the article "Parasitoids of *Ravinia belforti* (Prado & Fonseca, 1932) (Diptera: Sarcophagidae) in cattle dung in Itumbiara, GO", parasitoid abundance differed significantly among species ($\chi^2 = 12.50$; df = 3; p = 0.0059), with predominance of *S. nigroaenea*.

In the article "Fauna of parasitoids associated with Diptera Cyclorrhapha", total abundance did not differ significantly between forest and pasture ($\chi^2 = 1.58$; df = 1; p = 0.2089). However, the distribution of taxonomic groups differed significantly between environments ($\chi^2 = 37.21$; df = 3; $p < 0.0001$), and species distribution also differed significantly ($\chi^2 = 67.94$; df = 17; $p < 0.0001$).

In the article "Occurrence of *Trybliographa* sp. (Hymenoptera: Figitidae) as parasitoid of *O. thornax* in Brazil," comparison between parasitized and non-parasitized pupae was significant ($\chi^2 = 32.00$; df = 1; $p < 0.0001$), indicating that most pupae were not parasitized, although the host association was confirmed.

In the article "Microhymenopterans collected from pupae from cattle dung in three rural properties in southern Goiás", parasitoid abundance differed significantly among municipalities ($\chi^2 = 238.60$; df = 2; $p < 0.0001$). Parasitoid taxa also differed significantly in abundance ($\chi^2 = 900.50$; df = 13; $p < 0.0001$), and the distribution of taxa among municipalities was significant ($\chi^2 = 448.75$; df = 26; $p < 0.0001$). The original analyses showed significant host–parasitoid associations in Itumbiara ($\chi^2 = 61.00$; df = 16; $p < 0.05$), Cachoeira Dourada ($\chi^2 = 419.24$; df = 49; $p < 0.05$), and Panamá ($\chi^2 = 15.24$; df = 7; $p < 0.05$).

In the article “Occurrence of *P. vindemmiae* as parasitoid of *Megaselia scalaris* (Loew, 1866) (Diptera: Phoridae) in Brazil”, comparison between parasitized and non-parasitized pupae was significant ($\chi^2 = 22.50$; df = 1; $p < 0.0001$), confirming that most pupae were not parasitized, although the host association was recorded.

In the article “First report of *B. podagrica* parasitizing *Squamatoides trivittatus* Curran, 1927 (Diptera: Sarcophagidae) in Brazil”, parasitized and non-parasitized pupae differed significantly ($\chi^2 = 42.32$; df = 1; $p < 0.0001$), reflecting the low parasitism rate but confirming the new host association.

In the article “Pteromalidae parasitoids collected in cattle dung in Panamá, Goiás”, host abundance differed significantly among dipteran species ($\chi^2 = 54.92$; df = 6; $p < 0.0001$). Parasitoid abundance also differed significantly ($\chi^2 = 22.16$; df = 5; p = 0.0005), and parasitism differed among host species ($\chi^2 = 16.88$; df = 6; p = 0.0098). Host–parasitoid association was significant ($\chi^2 = 66.71$; df = 30; p = 0.0001), agreeing with the original result ($\chi^2 = 66.17$; df = 30; $p < 0.05$).

In the article “Eucoilinae collected in Lavras, Minas Gerais”, abundance differed significantly among Eucoilinae taxa ($\chi^2 = 26.53$; df = 6; p = 0.0002), with predominance of genus *Steleucoela* Kieffer, 1908 (Hymenoptera, Figitidae).

In the combined articles on “*M. raptor* and *P. vindemmiae* in pupae of *Palaeosepsis* spp. and *S. occidua*”, comparison between parasitized and non-parasitized pupae was significant for *Palaeosepsis* spp. ($\chi^2 = 569.24$; df = 1; $p < 0.0001$) and for *S. occidua* ($\chi^2 = 3139.11$; df = 1; $p < 0.0001$). These results indicate low parasitism but important new host records.

In the article “Eucoilinae parasitizing dipterous species developing in cattle dung in Panamá, Goiás”, the original chi-square showed significant host preference ($\chi^2 = 14.00$; df = 3; $p < 0.05$). *Kleidotoma nigra* (Hartig, 1840) (Hymenoptera: Figitidae) was associated with *Brontaea quadristigma* (Thomson, 1869) (Diptera: Muscidae), whereas *P. egeria, T. atrocoxalis*, and *T. coxalis* were associated with *Palaeosepsis* spp. (Figure 3).

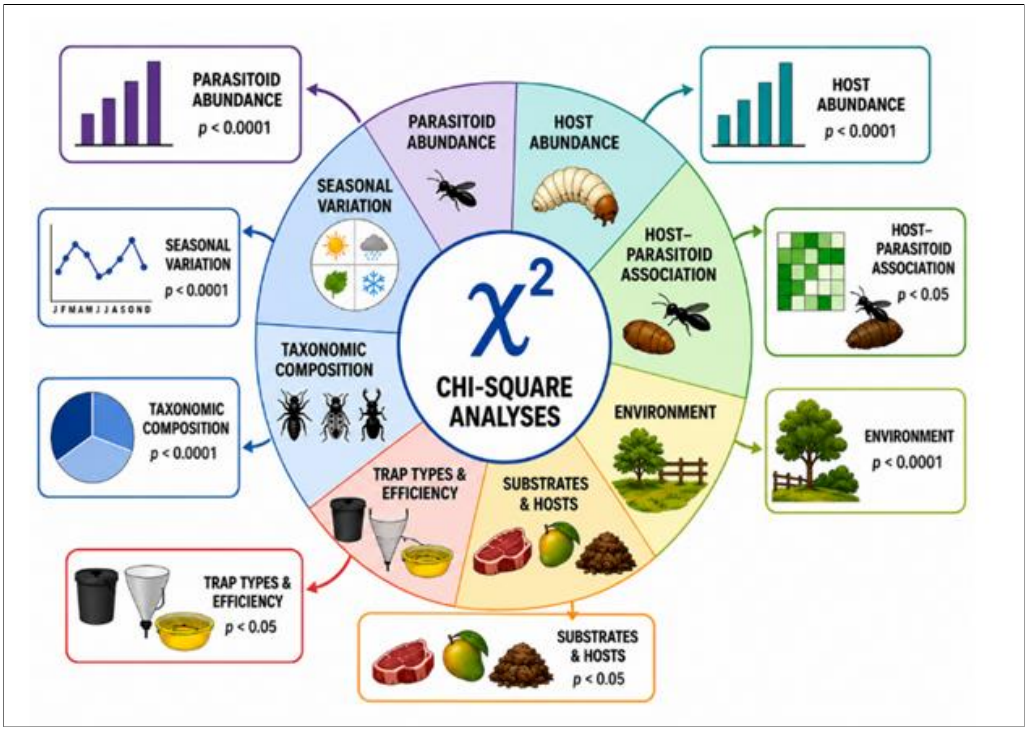

Figure 3: Integrated schematic summary of the chi-square analyses applied to parasitoid–host systems, substrates, habitats, sampling methods, seasonal variation, and dung beetle succession. The figure highlights that most comparisons showed non-random ecological patterns, including significant differences in parasitoid abundance, host abundance, host–parasitoid associations, substrate use, habitat distribution, trap efficiency, monthly occurrence, and exposure time of bovine dung

In the article “*G. quadridentata* as natural enemy of *Sarcodexia lambens* (Wiedemann, 1830) (Diptera: Sarcophagidae) in Brazil”, comparison between parasitized and non-parasitized pupae was not significant ($\chi^2 = 0.72$; df = 1; p = 0.3961), although the parasitism rate was biologically high at 56.0%.

In the article “Succession of Scarabaeidae on bovine dung in Itumbiara, Goiás”, Scarabaeidae abundance differed significantly among species ($\chi^2 = 13182.44$; df = 12; $p < 0.0001$). Abundance also differed significantly among dung exposure periods ($\chi^2 = 332.17$; df = 9; $p < 0.0001$). The original study reported significant species preference according to dung exposure time ($\chi^2 = 1421.26$; df = 99; $p < 0.0001$), confirming a clear successional pattern.

In the article "Families of parasitoids collected in southern Goiás using yellow pan and Malaise traps", Malaise traps collected significantly more parasitoids than yellow pan traps ($\chi^2 = 561.70$; df = 1; $p < 0.0001$). Family abundance differed significantly in yellow pan traps ($\chi^2 = 1594.36$; df = 20; $p < 0.0001$) and in Malaise traps ($\chi^2 = 8632.44$; df = 20; $p < 0.0001$). Family composition also differed significantly between trap types ($\chi^2 = 1208.53$; df = 20; $p < 0.0001$).

In the article "Hymenoptera parasitoids collected in southern Goiás and western Minas Gerais", parasitoid abundance differed significantly between regions ($\chi^2 = 668.60$; df = 1; $p < 0.0001$) and between trap types ($\chi^2 = 1606.86$; df = 1; $p < 0.0001$). Abundance also differed significantly among families ($\chi^2 = 32458.94$; df = 20; $p < 0.0001$), and the distribution of families among regions and trap types was significant ($\chi^2 = 5381.12$; df = 60; $p < 0.0001$).

In the article "Synanthropic flies of medical importance and their parasitoids collected in Itumbiara, Goiás", Diptera abundance differed significantly among species ($\chi^2 = 16574.30$; df = 19; $p < 0.0001$). Parasitoid abundance also differed significantly ($\chi^2 = 408.03$; df = 4; $p < 0.0001$), and parasitism differed significantly among hosts ($\chi^2 = 747.96$; df = 5; $p < 0.0001$). The original study also reported significant parasitoid–host preference ($\chi^2 = 104.09$; df = 20; $p < 0.05$). Monthly distribution was significant for Diptera ($\chi^2 = 4209.03$; df = 11; $p < 0.0001$) and parasitoids ($\chi^2 = 309.13$; df = 11; $p < 0.0001$).

In the article "Parasitoids of immature stages of synanthropic Diptera collected in several environments in Itumbiara, Goiás", parasitoid abundance differed significantly among environments ($\chi^2 = 1102.23$; df = 5; $p < 0.0001$), among species or taxa ($\chi^2 = 1072.05$; df = 17; $p < 0.0001$), and in the association between parasitoids and environments ($\chi^2 = 2593.56$; df = 85; $p < 0.0001$).

In the article "First occurrence of *Necrobia rufipes* (Fabricius, 1781) (Coleoptera: Cleridae) in dipteran pupae in Brazil", the comparison between pupae with and without *N. rufipes* was significant ($\chi^2 = 295.05$; df = 1; $p < 0.0001$). This result reflected the rarity of the association, although the record was biologically relevant.

Together, the chi-square analyses demonstrated that most ecological patterns observed in the reviewed studies were non-random. Significant differences were found for parasitoid abundance, host abundance, host–parasitoid associations, substrate use, habitat distribution, trap efficiency, monthly occurrence, and dung exposure time. These findings reinforce the importance of quantitative analyses in integrative reviews, especially when original studies presented descriptive data but did not always apply statistical tests. Overall, the complementary chi-square analyses provided additional support for interpreting parasitoid ecology, host specificity, environmental influence, and the potential role of parasitoids in biological control.

4.0. EXPERIMENTAL ARTICLES

1. Synanthropic Flies of Medical Importance and Their Parasitoids Collected in Itumbiara, State of Goiás, Brazil

A total of 5.808 synanthropic Diptera were collected in traps baited with bovine liver in Itumbiara, Goiás, Brazil. The specimens belonged to four families: Calliphoridae, Fanniidae, Muscidae, and Sarcophagidae. Muscidae was the most abundant family, with 2144 individuals and 36.91% of the total, followed by Fanniidae with 1698 individuals and 29.24%, Calliphoridae with 1403 individuals and 24.16%, and Sarcophagidae with 563 individuals and 9.69%. The distribution of individuals among families was significantly different (Table 2) ($\chi^2 = 917.43$; df = 3; $p < 0.0001$).

Table 2: Corrected abundance and relative frequency of synanthropic Diptera collected in traps baited with bovine liver in Itumbiara, Goiás, Brazil, from May 1998 to April 1999

Taxonomic group	Hosts species	Number of individuals	Frequency (%)
Calliphoridae	*Chrysomya albiceps*	501	8.63
	Chrysomya megacephala	785	13.52
	Chrysomya putoria	93	1.60
	Cochliomyia macellaria	24	0.41
Fanniidae	*Fannia pusio*	1698	29.24
Muscidae	*Atherigona orientalis*	1561	26.88
	Cyrtoneurina pararescita	2	0.03
	Musca domestica	451	7.77
	Ophyra aenescens	21	0.36
	Synthesiomyia nudiseta	109	1.88
Sarcophagidae	*Euboettcheria anguilla*	1	0.02
	Euboettcheria collusor	44	0.76
	Helicobia sp.	6	0.10

Taxonomic group	Hosts species	Number of individuals	Frequency (%)
	Liopygia ruficornis	1	0.02
	Oxysarcodexia thornax	154	2.65
	Peckia chrysostoma	223	3.84
	Ravinia belforti	9	0.15
	Sarcodexia lambens	110	1.89
	Sarcophagula sp.	6	0.10
	Sarcotachinella trivittata	9	0.15
Total	**-**	**5.808**	**100.00**

Among the dipteran species, *F. pusio* was the most abundant, representing 29.24% of all collected flies. It was followed by *A. orientalis* (26.88%), *C. megacephala* (13.52%), *C. albiceps* (8.63%), and *M. domestica* (7.77%). The abundance of Diptera differed significantly among species ($\chi^2 = 16574.30$; df = 19; $p < 0.0001$), indicating strong dominance of a few synanthropic species in the sampled area.

A total of 398 parasitoids emerged from dipteran pupae. The corrected overall parasitism rate was 6.85%. *N. vitripennis* was the most frequent parasitoid, with 223 individuals and 56.03% of the parasitoid fauna. It was followed by *B. podagrica*, with 106 individuals and 26.63%; *Hemencyrtus* sp., with 55 individuals and 13.82%; *S. endius*, with 13 individuals and 3.27%; and *P. vindemmiae*, with 1 individual and 0.25%. Parasitoid abundance differed significantly among species (Table 3) ($\chi^2 = 408.03$; df = 4; $p < 0.0001$).

Table 3: Corrected parasitoids associated with dipteran hosts collected in traps baited with bovine liver in Itumbiara, Goiás, Brazil, from May 1998 to April 1999

Host species	No. of pupae	Frequency (%)	Parasitoid species	Parasitized pupae	Frequency (%)	Parasitism rate (%)
Chrysomya albiceps	501	8.63	*Nasonia vitripennis*	184	46.23	36.73
Euboettcheria collusor	44	0.76	*Hemencyrtus* sp.	16	4.02	36.36
Fannia pusio	1698	29.24	*Spalangia endius*	10	2.51	0.59
			Pachycrepoideus vindemmiae	1	0.25	0.06
Oxysarcodexia thornax	154	2.65	*Nasonia vitripennis*	32	8.04	20.78
			Spalangia endius	3	0.75	1.95
Peckia chrysostoma	223	3.84	*Brachymeria podagrica*	106	26.63	47.53
Synthesiomyia nudiseta	109	1.88	*Nasonia vitripennis*	7	1.76	6.42
			Hemencyrtus sp.	39	9.80	35.78
Total	**5.808**	**100.00**	**-**	**398**	**100.00**	**6.85**

The highest parasitism rate was recorded for *B. podagrica* associated with *P. chrysostoma*, with 47.53%. High parasitism rates were also observed for *N. vitripennis* in *C. albiceps* (36.73%), *Hemencyrtus* sp. in *E. collusor* (36.36%), and *Hemencyrtus* sp. in *S. nudiseta* (35.78%). In contrast, the parasitism of *F. pusio* by *S. endius* and *P. vindemmiae* was very low, with rates below 1.0%.

The monthly distribution showed clear population peaks. Among Diptera, the highest numbers were observed mainly between November and January, particularly for *A. orientalis*, *C. albiceps*, *C. megacephala*, and *F. pusio*. Monthly abundance differed significantly among sampling months ($\chi^2 = 4153.73$; df = 11; $p < 0.0001$). Among parasitoids, *N. vitripennis* was concentrated mainly in May, July, September, and October, *B. podagrica* showed its highest abundance in April, and *Hemencyrtus* sp. occurred mainly in June and August. Parasitoid distribution also differed significantly among months (Table 4) ($\chi^2 = 309.13$; df = 11; $p < 0.0001$).

Table 4: Corrected monthly distribution of selected Diptera and parasitoids collected in traps baited with bovine liver in Itumbiara, Goiás, Brazil, from May 1998 to April 1999

Taxonomic group/species	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Total
Diptera													
Chrysomya albiceps	30	30	19	16	19	39	24	156	168	0	0	0	501
Chrysomya megacephala	63	12	11	42	14	16	16	485	113	0	11	2	785
Chrysomya putoria	22	2	0	3	2	2	3	24	33	0	2	0	93

Taxonomic group/species	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Total
Fannia pusio	553	45	70	66	42	189	214	95	185	74	36	129	1698
Atherigona orientalis	50	92	46	30	25	50	543	300	400	25	0	0	1561
Synthesiomyia nudiseta	10	12	18	19	12	13	5	10	9	1	0	0	109
Peckia chrysostoma	8	12	0	11	0	0	13	112	9	9	0	49	223
Sarcodexia lambens	7	7	6	2	6	5	20	22	30	0	2	3	110
Oxysarcodexia thornax	3	11	13	13	3	4	63	14	30	0	0	0	154
Total Diptera	**746**	**223**	**183**	**202**	**123**	**318**	**901**	**1218**	**977**	**109**	**51**	**183**	**5234**
Hymenoptera													
Brachymeria podagrica	4	0	9	6	4	13	6	10	8	0	0	46	106
Hemencyrtus sp.	0	26	3	26	0	0	0	0	0	0	0	0	55
Nasonia vitripennis	96	13	46	19	19	30	0	0	0	0	0	0	223
Total parasitoids	**100**	**39**	**58**	**51**	**23**	**43**	**6**	**10**	**8**	**0**	**0**	**46**	**384**

The corrected data show that the synanthropic fly community collected with bovine liver in Itumbiara was dominated by a few highly abundant species. Muscidae and Fanniidae were the most representative families, indicating that bovine liver was an efficient substrate for attracting medically important muscoid flies. The high abundance of *F. pusio* and *A. orientalis* is relevant from a sanitary perspective, because both are associated with organic matter and human-modified environments. The presence of Calliphoridae, especially *C. albiceps* and *C. megacephala*, also reinforces the medical and veterinary importance of the fauna, since these species may act as mechanical vectors of microorganisms.

Although Sarcophagidae showed the lowest abundance, this family contributed several species, indicating that abundance and species richness did not follow the same pattern. The parasitoid fauna was dominated by *N. vitripennis*, which was mainly associated with *C. albiceps*. *B. podagrica* was also important because of the high parasitism rate recorded in *P. chrysostoma*. In addition, *Hemencyrtus* sp. showed high parasitism in *S. nudiseta* and *E. collusor*, suggesting its potential role in the natural regulation of specific host populations (Figure 4).

Figure 4: Representative synanthropic flies and their parasitoids associated with traps baited with bovine liver in Itumbiara, Goiás, Brazil. The illustration shows adult Diptera attracted to the substrate, dipteran puparia, and hymenopteran parasitoids emerging from or attacking the pupae. This figure summarizes the host–parasitoid association observed in the study

The low parasitism of *F. pusio* by *S. endius* and *P. vindemmiae* indicates that high host abundance did not necessarily result in high parasitism. Although *F. pusio* was the most abundant dipteran species, it showed very low parasitism, probably due to host traits, pupation behavior, microhabitat conditions, or parasitoid preference.

The corrected results showed that the distribution of Diptera and parasitoids was not homogeneous among families, species, and months. The community was structured by dominant species and seasonal peaks. Fly abundance was higher during warmer and more humid periods, whereas parasitoid peaks did not always coincide with the greatest fly abundance. This suggests that parasitoid dynamics may depend on host stage availability, emergence timing, and host suitability. Overall, the data reinforce the medical importance of synanthropic flies and the role of parasitoids as natural enemies of dipteran pupae (Marchiori, 2001a).

2. Parasitoids of Dipterans Collected in Buffalo Feces on a Rural Property in Itumbiara, Goiás, Brazil

A total of 3.473 dipteran pupae were collected from buffalo dung in a rural property in Itumbiara, Goiás. Of these, 172 pupae were parasitized, corresponding to an overall parasitism rate of 5.0%. The dipteran hosts belonged mainly to Muscidae, Sarcophagidae, and Sepsidae, with the highest number of pupae recorded for *Palaeosepsis* spp. (1.948 pupae), followed by *S. occidua* (931 pupae), *A. scabra* (310 pupae), and *B. quadristigma* (138 pupae), *B. debilis* (127 pupae), and *C. pararescita* (19 pupae) (Table 5). The distribution of host pupae differed significantly among dipteran species ($\chi^2 = 4807.62$; df = 5; $p < 0.0001$), indicating a strong predominance of *Palaeosepsis* spp. and *S. occidua* in buffalo dung (Table 5).

Table 5: Parasitoids collected from dipteran pupae in buffalo dung in southern Goiás, Brazil, from May 2003 to June 2004

Diptera hosts	Number of pupae	Frequency (%)	Parasitoid species	Parasitized pupae	Parasitism rate (%)
Archisepsis scabra	310	8.9	*Paraganaspis egeria*	4	1.3
			Spalangia drosophilae	1	0.3
			Trichopria sp.	1	0.3
Brontaea quadristigma	138	4.0	*Paraganaspis egeria*	1	0.7
			Spalangia drosophilae	2	1.5
Brontaea debilis	127	3.7	*Spalangia cameroni*	2	1.6
			Spalangia nigroaenea	1	0.8
Cyrtoneurina pararescita	19	0.5	*Spalangia nigra*	1	5.3
			Spalangia nigroaenea	1	5.3
Palaeosepsis spp.	1.948	56.1	*Kleidotoma nigra*	6	0.3
			Paraganaspis egeria	12	0.6
			Spalangia cameroni	4	0.2
			Spalangia drosophilae	1	0.1
			Spalangia nigra	16	0.8
			Trichopria sp.	9	0.5
			Triplasta atrocoxalis	19	1.0
			Triplasta coxalis	8	0.4
Sarcophagula occidua	931	26.8	*Paraganaspis egeria*	11	1.2
			Spalangia cameroni	8	0.9
			Spalangia drosophilae	33	3.5
			Spalangia endius	4	0.4
			Spalangia nigroaenea	11	1.2
			Trichopria sp.	16	1.7
Total	**3.473**	**100.0**		**172**	**5.0**

Note: Frequency (%) was calculated using the total number of pupae (3.473).

Parasitism rates varied among host species. The highest parasitism rate was observed in *C. pararescita* (10.5%), although this host was represented by a low number of pupae. Among the most abundant hosts, *S. occidua* showed 83 parasitized pupae from 931 pupae, corresponding to 8.9%, while *Palaeosepsis* spp. showed 75 parasitized pupae from 1.948 pupae, corresponding to 3.9%. Other parasitism rates were 1.9% in *A. scabra*, 2.2% in *B. quadristigma*, and 2.4% in *B. debilis*. The comparison of parasitized and non-parasitized pupae among hosts showed a significant difference ($\chi^2 = 47.41$; df = 5; $p < 0.0001$), demonstrating that parasitism was not evenly distributed among host species.

The most abundant parasitoid was *S. drosophilae*, with 37 individuals (21.5%), followed by *P. egeria* with 28 individuals (16.3%), *Trichopria* sp. with 26 individuals (15.1%), *T. atrocoxalis* with 19 individuals (11.0%), *S. nigra* with 17 individuals (9.9%), *S. cameroni* with 14 individuals (8.1%), *S. nigroaenea* with 13 individuals (7.6%), *T. coxalis* with 8 individuals (4.7%), *K. nigra* with 6 individuals (3.5%), and *S. endius* with 4 individuals (2.3%). The abundance of parasitoid taxa differed significantly ($\chi^2 = 58.23$; df = 9; $p < 0.0001$), indicating unequal representation of parasitoid species in buffalo dung.

Host–parasitoid associations were also significant according to the chi-square test reported in the original study ($\chi^2 = 146.12$; df = 45; $p < 0.05$). *Spalangia drosophilae* occurred mainly in *S. occidua*, while *P. egeria* was recorded in *A. scabra*, *B. quadristigma*, *Palaeosepsis* spp., and *S. occidua*. *Spalangia cameroni, Spalangia nigra* Latreille, 1805 (Hymenoptera: Pteromalidae), *S. nigroaenea*, *Trichopria* sp., *T. atrocoxalis*, and *T. coxalis* were also associated with specific hosts, showing that parasitoid occurrence was influenced by host availability and host identity.

The results demonstrate that buffalo dung supports a diverse assemblage of dipteran hosts and parasitoids, although the overall parasitism rate was relatively low (5.0%). This value indicates that parasitoids were active in this substrate, but their effect on the total dipteran population was moderate. The high abundance of *Palaeosepsis* spp. and *S. occidua* suggests that buffalo dung provides favorable conditions for the development of these hosts, probably due to its physical structure, moisture, nutrient content, and persistence in the environment (Figure 5).

Figure 5: Schematic representation of parasitoids associated with dipteran pupae collected from buffalo feces on a rural property in Itumbiara, Goiás, Brazil. The figure illustrates buffalo dung as a substrate for dipteran development, the presence of puparia, and the emergence of parasitoids, emphasizing the ecological interaction between hosts and parasitoids in this substrate

The significant difference in host abundance shows that the dipteran community was not evenly distributed among species. *Palaeosepsis* spp. represented more than half of all pupae collected, while *S. occidua* was also highly abundant. This predominance is important because parasitoid populations depend directly on host availability. However, high host abundance did not always correspond to the highest parasitism rate. For example, *Palaeosepsis* spp. was the most abundant host but showed a lower parasitism rate than *C. pararescita* and *S. occidua*. This suggests that host suitability, parasitoid searching behavior, and microhabitat conditions may be more important than host abundance alone. The parasitoid community was dominated by *P. egeria*, followed by *S. drosophilae* and *Trichopria* sp.

The significant chi-square result for parasitoid abundance indicates that some parasitoid taxa were more successful or more frequently associated with buffalo dung than others. The predominance of *S. drosophilae* may be related to its ability to locate pupae in dung substrates and to exploit hosts developing in this environment. The presence of several pteromalid and figitid parasitoids also reinforces the ecological importance of dung as a habitat for natural enemies of synanthropic Diptera. The significant host–parasitoid association reported in the original study indicates that parasitoids did not use hosts randomly. Some parasitoids showed stronger associations with particular hosts, such as *S. drosophilae* with *S. occidua* and *P. egeria* with different Sarcophagidae and Sepsidae hosts (Marchiori *et al.,* 2007a).

3. Families of Parasitoids Collected in Wooded and Pasture Areas in the Municipality of Itumbiara, Goiás State, Brazil

A total of 7.080 parasitoid Hymenoptera were collected in pasture and native forest areas in Itumbiara, Goiás, Brazil. Of these, 4.093 individuals were collected in pasture areas, corresponding to 57.8%, and 2.987 individuals were collected in native forest areas, corresponding to 42.2%. The difference in total abundance between pasture and forest was statistically significant ($\chi^2 = 172.77$; df = 1; $p < 0.0001$), indicating a higher occurrence of parasitoids in pasture areas. The parasitoids were distributed among 21 families.

The most abundant families were Ichneumonidae, with 1.161 individuals (16.4%), Diapriidae, with 1.031 individuals (14.6%), Scelionidae, with 866 individuals (12.2%), Braconidae, with 646 individuals (9.1%), Encyrtidae, with 592 individuals (8.4%), Bethylidae, with 495 individuals (7.0%), Figitidae, with 452 individuals (6.4%), and Chalcididae, with 403 individuals (5.7%). The abundance of parasitoid families differed significantly ($\chi^2 = 7309.88$; df = 20; $p < 0.0001$), showing that the families were not equally represented in the sampled areas (Table 6).

Table 6: Abundance and relative frequency of parasitoid families collected in native forest and pasture areas in Itumbiara, Goiás, Brazil, from January to December 1998

Family	Native forest	Frequency (%)	Pasture	Frequency (%)	Total	Total frequency (%)
Agaonidae	0	0.0	1	0.0	1	0.0
Bethylidae	313	10.5	182	4.4	495	7.0
Braconidae	305	10.2	341	8.3	646	9.1
Ceraphronidae	106	3.5	201	4.9	307	4.3
Chalcididae	117	3.9	286	7.0	403	5.7
Diapriidae	458	15.3	573	14.0	1.031	14.6
Dryinidae	13	0.4	13	0.3	26	0.4
Encyrtidae	346	11.6	246	6.0	592	8.4
Eucharitidae	14	0.5	1	0.0	15	0.2
Eulophidae	69	2.3	153	3.7	222	3.1
Eupelmidae	26	0.9	35	0.9	61	0.9
Eurytomidae	0	0.0	1	0.0	1	0.0
Evaniidae	25	0.8	40	1.0	65	0.9
Figitidae	138	4.6	314	7.7	452	6.4
Ichneumonidae	332	11.1	829	20.3	1.161	16.4
Megaspilidae	7	0.2	66	1.6	73	1.0
Mymaridae	95	3.2	105	2.6	200	2.8
Platygastridae	84	2.8	60	1.5	144	2.0
Pteromalidae	154	5.2	150	3.7	304	4.3
Scelionidae	382	12.8	484	11.8	866	12.2
Torymidae	3	0.1	12	0.3	15	0.2
Total	**2.987**	**100.0**	**4.093**	**100.0**	**7.080**	**100.0**

Note: The numerical prefixes and suffixes associated with superfamily codes in the original table were removed from the family names. Percentages were calculated within each environment and for the total number of individuals.

The distribution of parasitoid families between forest and pasture areas also differed significantly ($\chi^2 = 404.54$; df = 20; $p < 0.0001$). Some families were more abundant in pasture, including Ceraphronidae, Chalcididae, Diapriidae, Eulophidae, Figitidae, Ichneumonidae, and Scelionidae. In contrast, some families, such as Bethylidae, Encyrtidae, Eucharitidae, Platygastridae, and Pteromalidae, showed higher or similar occurrence in forest areas. These results indicate that habitat type influenced the composition and abundance of parasitoid families (Figure 6).

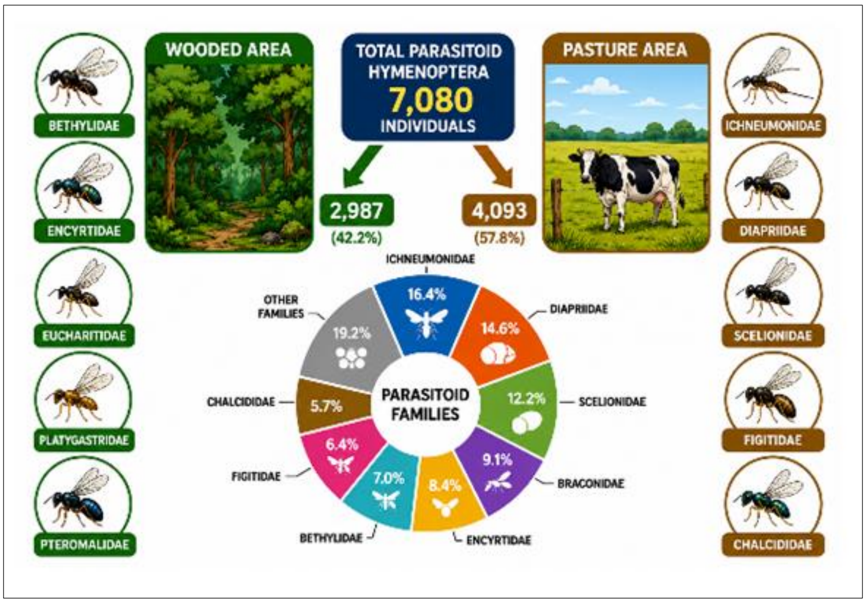

Figure 6: Schematic representation of parasitoid Hymenoptera collected in wooded and pasture areas in the municipality of Itumbiara, Goiás State, Brazil. The figure illustrates the two sampled habitats and the occurrence of parasitoid families, emphasizing the higher abundance recorded in pasture areas compared with wooded areas, as well as the broad family diversity associated with both environments

Seasonal variation was also observed. The highest monthly abundance occurred in August, with 977 individuals (13.8%), followed by October (919 individuals, 13.0%) and November (786 individuals, 11.1%). The lowest abundances were recorded in February (362 individuals; 5.1%) and January (369 individuals; 5.2%). The distribution of parasitoids among months differed significantly ($\chi^2 = 824.46$; df = 11; $p < 0.0001$), indicating seasonal variation in parasitoid occurrence throughout the year. Overall, the results show that pasture areas supported a higher abundance of parasitoids than native forest areas, although both environments contributed to parasitoid diversity. The significant chi-square results indicate that parasitoid abundance varied according to habitat, family, and month of collection.

The results demonstrate that pasture and native forest areas in Itumbiara supported a diverse community of parasitoid Hymenoptera. The higher abundance recorded in pasture areas suggests that these environments may provide favorable conditions for parasitoid occurrence, likely due to greater availability of host-associated cattle, organic matter, and open habitats. However, the presence of parasitoids in native forest areas also indicates the importance of preserved environments as reservoirs of natural enemies (Table 7).

Table 7: Seasonality of parasitoid Hymenoptera families collected in Itumbiara, Goiás, Brazil, from January to December 1998

Family	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total	Frequency (%)
Agaonidae	0	1	0	0	0	0	0	0	0	0	0	0	1	0.0
Bethylidae	44	26	21	14	29	27	46	75	69	53	60	31	495	7.0
Braconidae	23	84	108	79	54	69	68	63	23	13	23	39	646	9.1
Ceraphronidae	12	14	16	17	11	17	30	48	64	52	18	8	307	4.3
Chalcididae	19	11	21	19	21	35	29	143	27	18	30	30	403	5.7
Diapriidae	116	71	105	53	55	55	58	84	45	125	177	87	1.031	14.6
Dryinidae	1	0	1	0	1	9	3	3	5	3	1	0	27	0.4
Encyrtidae	4	5	18	39	74	108	87	116	37	35	28	41	592	8.4
Eucharitidae	2	0	1	2	1	2	1	0	0	3	1	0	13	0.2
Eulophidae	0	0	6	6	18	16	31	69	34	21	7	14	222	3.1
Eupelmidae	3	1	3	5	3	5	10	5	8	6	9	3	61	0.9
Eurytomidae	1	0	0	0	0	0	0	0	0	0	0	0	1	0.0
Evaniidae	9	4	3	4	2	3	3	6	4	11	15	1	65	0.9
Figitidae	38	27	42	28	23	25	15	29	16	67	74	68	452	6.4
Ichneumonidae	37	58	48	51	55	74	62	91	63	329	236	57	1161	16.4
Megaspilidae	1	1	1	1	1	1	25	32	7	1	1	1	73	1.0
Mymaridae	6	14	30	10	14	14	20	42	28	12	7	3	200	2.8
Platygastridae	28	24	29	7	10	9	10	7	5	10	1	4	144	2.0
Pteromalidae	9	12	47	13	19	40	35	47	25	29	22	8	306	4.3
Scelionidae	15	7	58	31	42	71	73	116	184	130	75	64	866	12.2
Torymidae	1	2	0	0	1	1	0	1	1	1	1	6	15	0.2
Total	**369**	**362**	**558**	**379**	**433**	**581**	**606**	**977**	**645**	**919**	**786**	**465**	**7.080**	**100.0**

Note: Monthly totals were preserved as reported in the original article. Minor inconsistencies caused by the printed table should be checked against the source before final submission.

The significant difference in total abundance between pasture and forest areas shows that parasitoid occurrence was not evenly distributed between habitats. This pattern may be related to differences in vegetation structure, host availability, microclimatic conditions, and resource distribution. Pasture areas may favor parasitoid activity by supporting insects associated with dung, grasses, and livestock environments, while forest areas may maintain parasitoid diversity through more stable ecological conditions and greater habitat complexity. The high abundance of Diapriidae, Ichneumonidae, and Scelionidae indicates that these families were important components of the parasitoid community. Ichneumonidae includes parasitoids associated with several insect groups and different developmental stages, while Diapriidae and Scelionidae are also important natural enemies in terrestrial ecosystems.

The significant difference among families confirms that parasitoid diversity was structured and not randomly distributed. Seasonal variation was evident, with higher parasitoid abundance in August, October, and November. This pattern suggests that climatic conditions, especially temperature, humidity, and rainfall, may influence parasitoid activity and host availability. The lower abundance in January and February may reflect seasonal fluctuations in host populations or unfavorable environmental conditions during part of the rainy season (Marchiori and Penteado-Dias, 2002).

4. Parasitoids of *P. Chrysostoma* Collected from Pupae on Bovine Kidney Substrate, Lavras, Minas Gerais, Brazil

A total of 942 pupae of *P. chrysostoma* were obtained from bovine kidney substrate in Lavras, Minas Gerais, Brazil. From these pupae, 921 parasitoids emerged, resulting in a natural parasitism prevalence of 97.0%. The parasitoid community was composed of seven taxa distributed in Braconidae, Chalcididae, Diapriidae, Encyrtidae, and Pteromalidae (Table 8).

Table 8: Parasitoids of *P. chrysostoma* collected in pupae from bovine kidney substrate in Lavras, Minas Gerais, Brazil

Taxonomic group	Parasitoid species	Number of parasitoids	Frequency (%)	Parasitism rate (%)
Braconidae	*Aphaereta* sp.	504	54.72	54.72
	Gnathopleura quadridentata	3	0.33	0.32
Chalcididae	*Brachymeria podagrica*	27	2.93	2.93
Diapriidae	*Trichopria* sp.	41	4.45	4.45
Encyrtidae	*Hemencyrtus herbertii*	220	23.89	23.89
Pteromalidae	*Nasonia vitripennis*	125	13.57	13.58
	Pachycrepoideus vindemmiae	1	0.11	0.11
Total		**921**	**100.00**	**100.00**

Note: Frequency (%) was calculated as the number of parasitoids of each species divided by the total number of parasitoids (921) multiplied by 100. The column Parasitism (%) follows the percentage values presented in the original table.

The most abundant parasitoid was *Aphaereta* sp., with 504 individuals (54.72%), followed by *H. herbertii* with 220 individuals (23.89%) and *N. vitripennis* with 125 individuals (13.58%). Other parasitoids occurred at lower frequencies: *Trichopria* sp. (41 individuals; 4.45%), *B. podagrica* (27 individuals; 2.93%), *G. quadridentata* (3 individuals; 0.32%), and *P. vindemmiae* (1 individual; 0.11%). The chi-square analysis showed a significant difference in the abundance of parasitoid taxa associated with *P. chrysostoma* ($\chi^2 = 1514.64$; df = 6; $p < 0.0001$).

This result indicates that parasitoid occurrence was not evenly distributed among taxa, with a strong predominance of *Aphaereta* sp., *H. herbertii*, and *N. vitripennis*. The results demonstrate that *P. chrysostoma* pupae collected from bovine kidney supported a highly abundant parasitoid assemblage. The high natural parasitism prevalence indicates that this substrate provided favorable conditions for host development and parasitoid activity. The presence of parasitoids from different families also shows that *P. chrysostoma* can act as an important host for several natural enemies in decomposing animal tissue. The predominance of *Aphaereta* sp. suggests a strong association between this parasitoid and *P. chrysostoma* in bovine kidney substrate.

The high frequency of *H. herbertii* and *N. vitripennis* is also ecologically relevant, especially because these taxa may show gregarious development, allowing several individuals to emerge from a single host. This biological characteristic helps explain the high number of parasitoids obtained from the collected pupae. The significant chi-square result confirms that parasitoid abundance was not randomly distributed among species. Instead, a few taxa were responsible for most of the parasitism observed, while other parasitoids occurred at low frequencies. This pattern indicates differences in host suitability, searching behavior, competitive ability, and adaptation to the substrate. Therefore, the parasitoid community associated with *P. chrysostoma* was structured by the dominance of a small number of highly frequent species (Figure 7) (Bonani *et al.,* 2006).

Figure 7: Schematic representation of parasitoids associated with *P. chrysostoma* pupae collected from bovine kidney substrate in Lavras, Minas Gerais, Brazil. The figure illustrates decomposing bovine kidney as a substrate for dipteran development, the presence of puparia, and the emergence of parasitoids, emphasizing the high natural parasitism recorded in this host–substrate system

5. Parasitism in *A. Fraterculus* in Brazil

A total of 190 pupae of *A. fraterculus* were obtained from star fruit and guava, and collected in Lavras, Minas Gerais, Brazil. From these pupae, 38 parasitoids emerged, resulting in an overall natural parasitism rate of 20.0%. Two figitid parasitoids were recorded: *A. pelleranoi*, with 20 individuals, representing 52.63% of the parasitoids and 10.53% parasitism, and *Dicerataspis grenadensis* Ashmead, 1895 (Hymenoptera: Figitidae), with 18 individuals, representing 47.37% and 9.47% parasitism rate. The difference in abundance between the two parasitoid taxa was not statistically significant ($\chi^2 = 0.11$; df = 1; $p = 0.7459$), indicating a similar contribution of both parasitoids to the parasitism of *Anastrepha* sp. pupae. The article reports these values with 20 *A. pelleranoi* and 18 *D. grenadensis,* totaling 38 parasitoids and 20.0% parasitism (Figure 8).

Figure 8: Schematic representation of parasitism in *A. fraterculus* developing in guava fruits in Brazil. The figure illustrates guava as the host fruit, the formation of puparia, and the emergence of the figitid parasitoids *A. pelleranoi,* emphasizing their similar contribution to the natural parasitism of fruit-fly pupae in this system. *Dicerataspis grenadensis* is associated with *A. fraterculus* larvae developing in star fruit in Brazil. The illustration shows infested carambola fruits, fruit fly larvae feeding in the pulp, pupae, and adult tephritid flies. This figure summarizes the host–parasitoid relationship involving *D. grenadensis* in fruit-infesting Tephritidae

The results show that *A. fraterculus* pupae developing in guava fruits supported a relatively high level of natural parasitism, with an overall rate of 20.0%. This indicates that guava orchards may provide favorable conditions for the occurrence of parasitoids associated with fruit flies, probably due to the availability of host larvae and pupae within infested fruits. The presence of *A. pelleranoi* and *D. grenadensis* reinforces the importance of Figitidae as natural enemies of tephritid fruit flies in fruit-based systems. Although *A. pelleranoi* was slightly more frequent than *D. grenadensis*, the chi-square analysis showed no significant difference between the two taxa.

The wasp *D. grenadensis* is a micro-hymenopteran (family Figitidae, subfamily Eucoilinae) that acts as a parasitoid of fruit fly larvae. They act as natural enemies of dipterans, commonly associated with the fruit fly *A. fraterculus* and the African fig fly *Z. indianus* It has a wide distribution in the Americas, being recorded from the Caribbean (Grenada, where it was discovered in 1896) to Nearctic and Neotropical regions, including a strong presence in Brazil, such as in the states of São Paulo, Minas Gerais, and Pará. This suggests that both parasitoids contributed similarly to the natural parasitism observed in the study. The close values recorded for frequency and parasitism indicate that these parasitoids may coexist in the same host system, exploiting *A. fraterculus* pupae under similar ecological conditions (Figure 9) (Costa *et al.,* 2007).

Figure 9: *Dicerataspis grenadensis* are parasitoid wasps belonging to the subfamily Eucoilinae (family Figitidae, superfamily Cynipoidea). They act as important biological control agents, developing as endoparasitoids in the larvae of fruit flies. Source: blowflies/*Drosophila*

6. Parasitoids of *R. Belforti* in Cattle Feces in Itumbiara, GO, Brazil

A total of 71 pupae of *R. belforti* were collected from fresh bovine feces in a rural area of Itumbiara, Goiás, Brazil. From these pupae, 16 parasitoids emerged, resulting in an overall parasitism rate of 22.5%. Four parasitoid species were recorded: *P. vindemmiae*, with 3 individuals (18.75%); *S. cameroni*, with 1 individual (6.25%); *S. nigra*, with 2 individuals (12.5%); and *S. nigroaenea*, with 10 individuals (62.5%). The article reports these same values in the abstract and results section, identifying *S. nigroaenea* as the most frequent parasitoid associated with *R. belforti*.

The distribution of parasitoid abundance differed significantly among species ($\chi^2 = 12.50$; df = 3; $p = 0.0059$), indicating that parasitoid occurrence was not evenly distributed. The predominance of *S. nigroaenea* suggests a stronger association with *R. belforti* pupae in bovine feces under the sampled conditions. Considering parasitized and non-parasitized pupae, the number of non-parasitized pupae was higher than parasitized pupae, but the parasitism rate of 22.5% indicates relevant natural parasitoid activity in this substrate (Figure 10).

Figure 10: Schematic representation of parasitoids associated with *R. belforti* pupae collected from fresh bovine feces in a rural area of Itumbiara, Goiás, Brazil. The figure illustrates bovine feces as the developmental substrate, the presence of dipteran puparia, and the emergence of parasitoids, emphasizing the natural parasitism recorded in this host–substrate system

The results show that bovine feces can support natural parasitism of *R. belforti* by different pteromalid parasitoids. The overall parasitism rate of 22.5% indicates that parasitoids may contribute to the natural regulation of this sarcophagid fly in cattle environments. This is ecologically relevant because *R. belforti* develops in organic substrates associated with livestock systems, where synanthropic flies may have sanitary and veterinary importance. Among the parasitoids recorded, *S. nigroaenea* was clearly dominant, representing 62.5% of the parasitoids obtained. The significant chi-square result confirms that the parasitoid species were not equally represented, reinforcing the predominance of *S. nigroaenea* in this host–substrate system.

This pattern may be related to host suitability, searching behavior, substrate characteristics, or the ability of this parasitoid to locate pupae in bovine feces. However, the strong predominance of *S. nigroaenea* suggests that parasitoid efficiency may vary among species, even when they share the same host and substrate. The record of *S. cameroni* is particularly important because the article reports this as the first record of this parasitoid in pupae of *R. belforti* in Brazil (Marchiori *et al.,* 2006b).

7. Fauna of Parasitoids Associated with Diptera Cyclorrhapha (Insecta) in Brazil

A total of 183 parasitoid Hymenoptera were collected using yellow pan traps in forest and pasture areas in Itumbiara, Goiás, Brazil. Of these, 100 individuals were collected in the forest area and 83 in the pasture area. The difference in total abundance between forest and pasture was not statistically significant ($\chi^2 = 1.58$; df = 1; $p = 0.2089$), indicating that overall parasitoid abundance was similar between the two environments (Table 9).

Table 9: Parasitoids collected in forest and pasture areas in Itumbiara, Goiás, Brazil

Taxonomic group	Forest (n)	Forest frequency (%)	Pasture (n)	Pasture frequency (%)
Alysiinae				
Aphaereta sp.	17	17.0	7	8.4
Asobara sp.	25	25.0	3	3.6
Dinotrema sp.	0	0.0	2	2.4

Taxonomic group	Forest (n)	Forest frequency (%)	Pasture (n)	Pasture frequency (%)
Microcrasis sp.	0	0.0	1	1.2
Phaenocarpa sp.	13	13.0	1	1.2
Total Alysiinae	**55**	**55.0**	**14**	**16.9**
Eucoilinae				
Agrostocynips sp.	0	0.0	1	1.2
Dettmeria sp.	0	0.0	3	3.6
Dieucoila sp.	1	1.0	1	1.2
Aganaspis pelleranoi	0	0.0	2	2.4
Odonteucoila sp.	9	9.0	1	1.2
Paraganaspis egeria	4	4.0	5	6.0
Triplasta atrocoxalis	1	1.0	6	7.2
Zaeucoila sp.	20	20.0	15	18.1
Total Eucoilinae	**35**	**35.0**	**34**	**41.0**
Figitinae				
Neralsia splendens	0	0.0	1	1.2
Total Figitinae	0	0.0	1	1.2
Pteromalidae				
Spalangia cameroni	8	8.0	32	38.6
Spalangia endius	1	1.0	0	0.0
Spalangia drosophilae	0	0.0	1	1.2
Spalangia nigra	1	1.0	1	1.2
Total Pteromalidae	**10**	**10.0**	**34**	**41.0**
Total	**100**	**100.0**	**83**	**100.0**

Note: Frequencies were calculated separately for each environment, using forest = 100 and pasture = 83 individuals.

The parasitoids were distributed among four main taxonomic groups: Alysiinae, Eucoilinae, Figitinae, and Pteromalinae. Alysiinae was more abundant in the forest area, with 55 individuals, corresponding to 55.0% of the forest sample, whereas Eucoilinae and Spalanginae were more frequent in pasture, each with 34 individuals, corresponding to 41.0% of the pasture sample. The distribution of taxonomic groups differed significantly between forest and pasture ($\chi^2 = 37.21$; df = 3; $p < 0.0001$), showing that habitat type influenced parasitoid composition. At the species level, the distribution of parasitoids also differed significantly between forest and pasture ($\chi^2 = 67.94$; df = 17; $p < 0.0001$).

In the forest area, the most abundant taxa were *Asobara* sp. with 25 individuals (25.0%), *Zaeucoila* sp. with 20 individuals (20.0%), *Aphaereta* sp. with 17 individuals (17.0%), and *Phaenocarpa* sp. with 13 individuals (13.0%). In the pasture area, *S. cameroni* was the most abundant species, with 32 individuals (38.6%), followed by *Zaeucoila* sp. with 15 individuals (18.1%), *Aphaereta* sp. with 7 individuals (8.4%), and *T. atrocoxalis* with 6 individuals (7.2%) (Figure 11).

Figure 11: Schematic representation of the parasitoid fauna associated with Cyclorrhapha Diptera in forest and pasture areas in Itumbiara, Goiás, Brazil. The figure illustrates the two sampled habitats, the use of yellow pan traps, and the occurrence of parasitoid Hymenoptera, emphasizing that overall abundance was similar between habitats, whereas taxonomic composition differed between forest and pasture environments. Forest areas were characterized mainly by Alysiinae, whereas pasture areas showed a higher representation of Pteromalidae, especially *S. cameroni*

These results indicate that the forest area favored mainly Alysiinae, especially *Aphaereta* sp., *Asobara* sp., and *Phaenocarpa* sp., whereas the pasture favored Pteromalidae, especially *S. cameroni*. Eucoilinae occurred in both habitats, with similar total abundance, but some genera showed habitat-related differences. The results demonstrate that forest and pasture areas supported distinct parasitoid assemblages, even though total abundance did not differ significantly between the two habitats. This indicates that both environments contributed to parasitoid occurrence, but the composition of taxa varied according to habitat type.

The significant chi-square result for taxonomic groups confirms that parasitoid distribution was not random between forest and pasture. The higher abundance of Alysiinae in the forest suggests that native vegetation may provide favorable ecological conditions for this group, possibly due to greater habitat complexity, host diversity, and microclimatic stability. Taxa such as *Aphaereta* sp., *Asobara* sp., and *Phaenocarpa* sp. were more frequent in the forest, reinforcing the role of native vegetation as a reservoir of parasitoid diversity. In contrast, pasture areas showed a higher frequency of Pteromalidae, particularly *S. cameroni*. This pattern may be associated with the availability of hosts developing in pasture-related substrates and livestock environments.

The strong predominance of *S. cameroni* in pasture suggests that open environments and host availability may favor this parasitoid under the sampled conditions. The significant species-level chi-square analysis reinforces that parasitoid occurrence was structured by habitat. Some taxa occurred mainly in the forest, whereas others were concentrated in the pasture. This habitat-related distribution highlights the importance of maintaining heterogeneous landscapes, including both native vegetation and pasture areas, to preserve parasitoid diversity and ecological interactions (Marchiori *et al.,* 2000e).

8. Occurrence of *Trybliographa* sp. (Hymenoptera: Figitidae) as a Parasitoid of *O. Thornax* in Brazil

A total of 50 pupae of *O. thornax* were collected from human feces in Itumbiara, Goiás, Brazil. From these pupae, 5 specimens of *Trybliographa* sp. emerged, resulting in an overall parasitism rate of 10.0%. This record represents the first occurrence of *Trybliographa* sp. parasitizing *O. thornax* in Brazil. The original article reports that the pupae were obtained using pitfall traps baited with human feces and that each pupa was individualized in gelatin capsules until the emergence of flies or parasitoids. Because only one parasitoid taxon was recorded, it was not appropriate to compare parasitoid species by chi-square. However, considering parasitized and non-parasitized pupae, the difference was significant ($\chi^2 = 32.00$; df = 1; $p < 0.0001$), with 45 non-parasitized pupae and 5 parasitized pupae. This result indicates that most pupae did not produce parasitoids, although the occurrence of *Trybliographa* sp. confirms its association with *O. thornax* under the sampled conditions (Figure 12).

Figure 12: Schematic representation of the occurrence of *Trybliographa* sp. as a parasitoid of *O. thornax* in Itumbiara, Goiás, Brazil. The figure illustrates a pitfall trap baited with human feces, the recovery of dipteran puparia, the individualization of pupae in gelatin capsules, and the emergence of the parasitoid, emphasizing the host–parasitoid association recorded in this substrate

The occurrence of *Trybliographa* sp. in pupae of *O. thornax* expands the knowledge of host–parasitoid associations involving sarcophagid flies in Brazil. Although the parasitism rate was moderate, at 10.0%, the record is relevant because it represents the first report of this parasitoid associated with *O. thornax* using human feces as bait. This indicates that decomposing organic substrates may support not only dipteran development but also the occurrence of their natural enemies. The low number of parasitized pupae compared with non-parasitized pupae suggests that parasitism was not highly frequent in this sample. However, the presence of *Trybliographa* sp. demonstrates that this parasitoid can locate and develop in hosts associated with human feces. Such substrates are important in ecological and sanitary studies because they attract synanthropic Diptera, including species of medical and veterinary relevance (Marchiori *et al.,* 2005a).

9. Microhymenopterans Collected from Pupae Originating from Cattle Feces on Three Rural Properties in the Southern Region of the State of Goiás, Brazil

A total of 9.657 dipteran pupae were collected from cattle dung in three rural properties in southern Goiás, Brazil. From these pupae, 711 parasitoids emerged, corresponding to an overall parasitism rate of 7.36%. The parasitoids were collected in three municipalities: 78 individuals in Panamá, 213 in Cachoeira Dourada, and 410 in Itumbiara. The abundance of parasitoids differed significantly among municipalities (χ^2 = 238.60; df = 2; p < 0.0001), indicating higher parasitoid occurrence in Itumbiara. The article reports the same total of 711 parasitoids and an overall parasitism rate of 7.36% (Table 10).

Table 10: Parasitism obtained from dipteran pupae collected from cattle feces in Itumbiara, GO, Brazil

Host species	Number of pupae	Parasitoid species	Number of individuals	Parasitism rate (%)
Brontaea quadristigma	720	*Muscidifurax* sp.	1	0.14
		Paraganaspis egeria	1	0.14
		Spalangia cameroni	18	2.50
		Spalangia endius	8	1.11
		Spalangia nigroaenea	18	2.50
		Spalangia sp.	7	1.00
		Trichopria sp.	3	0.42
Brontaea debilis	452	*Spalangia cameroni*	4	0.90
		Spalangia nigroaenea	4	0.90
		Spalangia sp.	3	0.70
Cyrtoneurina pararescita	2.362	*Spalangia cameroni*	1	0.04
		Spalangia endius	2	0.08
		Spalangia nigroaenea	10	0.42
		Spalangia sp.	2	0.08
Palaeosepsis spp.	307	*Muscidifurax* sp.	1	0.33
		Spalangia cameroni	3	1.00
		Spalangia drosophilae	137	44.6
		Spalangia endius	3	1.00
		Spalangia nigroaenea	3	1.00
		Spalangia sp.	3	1.00
		Trichopria sp.	27	8.80
		Triplasta atrocoxalis	67	21.8
Sarcophagula occidua	2.006	*Paraganaspis egeria*	31	1.55
		Spalangia cameroni	8	0.40
		Spalangia drosophilae	17	0.85
		Spalangia endius	4	0.20
		Spalangia nigra	1	0.05
		Spalangia nigroaenea	10	0.50
		Spalangia sp.	2	0.10
		Trichopria sp.	8	0.40
		Triplasta atrocoxalis	4	0.20
Sphaeroceridae	37	*Trichopria* sp.	8	21.6
		Triplasta atrocoxalis	1	2.70
Total	**5.884**		**711**	**7.36**

The most frequent parasitoid species were *S. drosophilae*, with 219 individuals (30.8%), followed by *T. atrocoxalis*, with 115 individuals (16.2%), *Trichopria* sp., with 88 individuals (12.4%), *S. nigroaenea*, with 71 individuals (10.0%), *P. egeria*, with 53 individuals (7.5%), *S. nigra*, with 45 individuals (6.3%), and *S. cameroni*, with 39 individuals (5.5%). The abundance of parasitoid taxa differed significantly (χ^2 = 900.50; df = 13; p < 0.0001), showing that the parasitoid community was not evenly distributed among species. The distribution of parasitoid taxa among the three municipalities was also significantly different (χ^2 = 448.75; df = 26; p < 0.0001).

In Itumbiara, *S. drosophilae* were the most abundant species, with 154 individuals, followed by *T. atrocoxalis* with 72, *Trichopria* sp. with 46, and S. nigroaenea with 45. In Cachoeira Dourada, *S. drosophilae* were also abundant, with 58 individuals, followed by *T. atrocoxalis* and *Trichopria* sp., both with

41 individuals. In Panamá, the most frequent parasitoids were *G. quadridentata* with 20 individuals, *S. nigroaenea* with 18, and *T. coxalis* with 8 (Table 11).

Table 11: Parasitism obtained from dipteran pupae collected from cattle feces in Cachoeira Dourada, GO

Host species	Number of pupae	Parasitoid species	Number of individuals	Parasitism rate (%)
Archisepsis scabra	129	*Spalangia drosophilae*	6	4.65
		Triplasta atrocoxalis	8	6.20
Brontaea debilis	95	*Spalangia nigra*	1	1.05
Coproica sp.	340	*Trichopria* sp.	30	8.82
Cyrtoneurina pararescita	302	*Paraganaspis egeria*	2	0.66
		Spalangia endius	3	0.99
		Spalangia nigroaenea	2	0.66
Haematobia irritans	28	*Paraganaspis egeria*	1	3.57
		Trichopria sp.	5	17.9
Musca domestica	227	*Spalangia nigroaenea*	3	1.32
Palaeosepsis spp.	1,197	*Spalangia drosophilae*	42	3.50
		Trichopria sp.	4	0.33
		Triplasta atrocoxalis	32	2.67
Sarcophagula occidua	827	*Paraganaspis egeria*	16	1.93
		Spalangia cameroni	1	0.12
		Spalangia drosophilae	10	1.21
		Spalangia endius	5	0.60
		Spalangia nigra	36	4.35
		Spalangia nigroaenea	3	0.36
		Trichopria sp.	2	0.24
		Triplasta atrocoxalis	1	0.12
Total	**3.145**		**213**	**6.77**

In Itumbiara, parasitoid preference for hosts was significant according to the original chi-square analysis ($\chi^2 = 61.00$; df = 16; $p < 0.05$). *Triplasta atrocoxalis* showed a preference for pupae of *Palaeosepsis* spp.; *P. egeria* for pupae of *S. occidua; S. cameroni* for pupae of *B. quadristigma* and *M. domestica*; *S. drosophilae* for pupae of *Palaeosepsis* spp.; and *S. endius* for pupae of *B. quadristigma*, *C. pararescita*, and *S. occidua.*

In Cachoeira Dourada, host–parasitoid associations were also significant ($\chi^2 = 419.24$; df = 49; $p < 0.05$). *S. drosophilae* were associated with *A. scabra* and *Palaeosepsis* spp.; *S. endius* with pupae of *C. pararescita* and *S. occidua*; *S. nigra* with *S. occidua*; *S. nigroaenea* with *C. pararescita*, *M. domestica*, and *S. occidua*; *T. atrocoxalis* with *A. scabra* and *Palaeosepsis* spp.; and *Trichopria* sp. with pupae of *Haematobia irritans* L. 1758 (Diptera: Muscidae) and *Coproica* sp. (Diptera: Sphaeroceridae) (Figure 13).

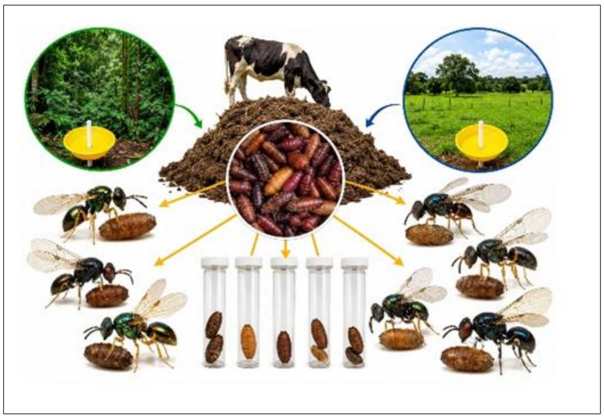

Figure 13: Schematic representation of microhymenopteran parasitoids emerging from dipteran pupae collected in cattle feces from three rural properties in southern Goiás, Brazil. The figure illustrates cattle dung as the substrate, the recovery and individualization of pupae, and the emergence of parasitoids, emphasizing the diversity of parasitoid assemblages and the variation in occurrence among the sampled municipalities

In Panamá, host–parasitoid associations were also significant ($\chi^2 = 15.24$; df = 7; $p < 0.05$). *Gnathopleura quadridentata* showed a preference for pupae of *O. thornax; K. nigra* for *B. quadristigma; P. vindemmiae* for *Palaeosepsis* spp.; *S. cameroni* for *B. debilis* and *M. domestica*; *S. drosophilae* for *A. scabra* and *M. domestica*; *S. endius* for *B. quadristigma* and *Palaeosepsis* spp.; *S. nigra* for *C. pararescita* and *R. belforti*; and *S. nigroaenea* for *B. debilis, B. quadristigma, C. pararescita*, and *R. belforti* (Table 12).

Table 12: Parasitism obtained from dipteran pupae collected from cattle feces in Panamá, GO

Host species	Number of pupae	Parasitoid species	Number of individuals	Parasitism rate (%)
Archisepsis scabra	40	*Spalangia drosophilae*	4	10.0
Brontaea debilis	56	*Spalangia cameroni*	1	1.79
		Spalangia nigroaenea	2	3.57
Brontaea quadristigma	49	*Kleidotoma nigra*	2	4.08
		Spalangia cameroni	1	2.04
		Spalangia drosophilae	1	2.04
		Spalangia endius	1	2.04
		Spalangia nigroaenea	5	10.2
Cyrtoneurina pararescita	151	*Spalangia nigra*	3	1.99
		Spalangia nigroaenea	5	3.31
Musca domestica	10	*Spalangia cameroni*	1	10.0
Oxysarcodexia thornax	70	*Gnathopleura quadridentata*	20	28.6
Palaeosepsis spp.	107	*Paraganaspis egeria*	2	1.87
		Spalangia drosophilae	2	1.87
		Spalangia endius	1	0.93
		Triplasta atrocoxalis	2	1.87
		Triplasta coxalis	8	7.48
		Trichopria sp.	1	0.93
Ravinia belforti	63	*Pachycrepoideus vindemmiae*	5	7.94
		Spalangia cameroni	1	1.59
		Spalangia nigra	4	6.35
		Spalangia nigroaenea	6	9.52
Sarcophagula occidua	31	-	-	-
Total	**628**		**78**	**14.0**

The results demonstrate that cattle dung supported a diverse assemblage of microhymenopteran parasitoids associated with dipteran pupae in the three rural properties studied. Although parasitoids were recorded in all municipalities, their abundance differed significantly, with Itumbiara showing the highest number of individuals. This pattern may be related to differences in host availability, local environmental conditions, cattle management, substrate quality, and microhabitat characteristics.

The predominance of *S. drosophilae* indicates that this species was highly adapted to hosts developing in cattle dung. Its high abundance in Itumbiara and Cachoeira Dourada suggests that it may be an important natural enemy of dung-breeding Diptera in southern Goiás. The occurrence of *P. egeria, S. nigroaenea*, *T. atrocoxalis*, and *Trichopria* sp. also demonstrates that cattle dung provides ecological conditions suitable for parasitoids from different taxonomic groups.

The significant chi-square result for parasitoid abundance shows that the parasitoid community was not evenly distributed among taxa. A few species were dominant, while others occurred at low frequencies. This pattern is common in parasitoid communities and may reflect differences in host specificity, searching ability, reproductive strategy, seasonal occurrence, and adaptation to cattle dung substrates. The significant association between parasitoid taxa and municipalities indicates that each rural property supported a different parasitoid assemblage.

Itumbiara was characterized by a high abundance of *S. drosophilae* and *T. atrocoxalis*, while Cachoeira Dourada also showed strong representation of *S. drosophilae*, *T. atrocoxalis*, and *Trichopria* sp. In Panamá, the composition differed, with a greater representation of *G. quadridentata*, *S. nigroaenea*, and *T. coxalis*. These differences suggest that local ecological conditions influenced parasitoid composition. The host–parasitoid associations reported for Itumbiara, Cachoeira Dourada, and Panamá indicate that parasitoids did not select hosts at random. Instead, several parasitoids showed preference for specific dipteran hosts, such as *B. quadristigma*, *M. domestica*, *O. thornax*, *Palaeosepsis* spp., *R. belforti,* and *S. occidua*. These associations indicate that host identity and substrate conditions are important factors structuring parasitoid occurrence (Marchiori *et al.,* 2005b).

10. Occurrence of *P. Vindemmiae* as a Parasitoid of *M. Scalaris* in Brazil

A total of 40 *M. scalaris* pupae were collected at the municipal slaughterhouse in Morrinhos, Goiás, Brazil, using dark-colored metal containers baited with bovine kidney. From these pupae, five specimens of *P. vindemmiae* emerged, resulting in a parasitism rate of 13.0%. This record represents the first occurrence of *P. vindemmiae* parasitizing pupae of *M. scalaris* in Brazil. The original article reports the same values: five *P. vindemmiae* specimens obtained from 40 pupae of *M. scalaris*, with observed parasitism of 13.0%. Because only one parasitoid species was recorded, comparison among parasitoid taxa was not applicable.

However, considering parasitized and non-parasitized pupae, the difference was significant (χ^2 = 22.50; df = 1; $p < 0.0001$), with 5 parasitized pupae and 35 non-parasitized pupae. This result indicates that most pupae did not produce parasitoids, although the occurrence of *P. vindemmiae* confirms its association with *M. scalaris* under the sampled conditions. The occurrence of *P. vindemmiae* in pupae of *M. scalaris* expands the knowledge of host associations involving this parasitoid in Brazil. Although the parasitism rate was moderate, the record is relevant because *M. scalaris* is a phorid fly commonly associated with decomposing organic matter and animal residues. The use of bovine kidney as bait likely favored the attraction and development of this host, creating suitable conditions for parasitoid occurrence (Figure 14).

Figure 14: Schematic representation of the occurrence of *P. vindemmiae* as a parasitoid of *M. scalaris* in Morrinhos, Goiás, Brazil. The figure illustrates the dark-colored metal trap baited with bovine kidney, the collection of dipteran puparia in a slaughterhouse environment, and the emergence of the parasitoid from the host puparium, emphasizing the host–parasitoid association recorded in this study

The parasitism rate of 13.0% indicates that *P. vindemmiae* may contribute to the natural regulation of *M. scalaris* populations in environments associated with animal organic matter. This parasitoid is known for its broad host range and ability to parasitize pupae of several Diptera families. Its occurrence in *M. scalaris* reinforces its ecological plasticity and its potential importance as a natural enemy in synanthropic environments. The significant chi-square result comparing parasitized and non-parasitized pupae shows that non-parasitized pupae were predominant in the sample. However, the detection of *P. vindemmiae* in this host remains important because it represents a new host record. Such records are valuable for understanding parasitoid biodiversity, host range, and possible applications in biological control programs involving flies associated with decomposing substrates (Marchiori and Barbaresco, 2007b).

11. Survey of Coleoptera (Arthropoda: Insecta) Associated with cattle Feces in the Municipality of Itumbiara, Goiás, Brazil

A total of 12.068 specimens of Coleoptera associated with bovine feces were collected in Itumbiara, Goiás, Brazil. The most abundant families were Staphylinidae, with 5.452 individuals (45.2%), Scarabaeidae, with 4,884 individuals (40.4%), and Histeridae, with 1,445 individuals (11.9%). Other families were represented by lower numbers of individuals, including Hydrophilidae (281), Carabidae (4), Anthicidae (2), and Nitidulidae (1). The distribution of abundance among families differed significantly (χ^2 = 20262.87; df = 6; $p < 0.0001$), indicating that Coleoptera were not evenly distributed among taxonomic groups (Table 13).

Table 13: Coleoptera associated with bovine feces collected in Itumbiara, Goiás, Brazil

Taxonomic group	Frequency (%)	Taxonomic group	Frequency (%)
Coleoptera:		*Ataenius aequalis*	4.001
		Ateuchus striatulus	371
Anthicidae		*Dichotomius bos*	18
		Digitonthophagus gazella	73
species 1	2	*Euparia* sp.	45
		Leucothyreus sp.	2
Carabidae		*Onthophagus hircullus*	2
species 1	2	**Total**	**4.884**
species 2	2		
Total	**4**		
Hydrophilidae		Staphylinidae	
Species	281	*Aleochara notula*	3
		Heterothops sp.	415
		Oxytelus sp.	3895
		Philonthus sp.	660
		species 1	62
Histeridae		species 2	22
Acritus sp.	316	species 3	84
Hister dubius	8	species 10	5
Phelister sp.	441	species 11	6
species 1	492	species 4	5
species 2	1	species 5	2
species 3	180	species 6	188
species 4	1	species 7	22
species 5	2	species 8	45
species 6	4	species 9	2
Total	**1.445**	species 12	4
		species 13	3
Nitidulidae		species 14	2
species 1	1	species 15	2
		species 16	20
Scarabaeidae		species 17	1
Aphodius nigrita	4	species 19	2
Aphodius lividus	328	species 20	1
Aphodius sp.	14	species 18	1
Ataenius sp. 1	18	-	-
Ataenius sp. 2	3	-	-
Ataenius sp. 3	3	-	-
Ataenius sp. 5	1	**Total**	**5.452**
Ataenius sp. 6	1	**Total**	**12.068**

Note: Frequency represents the number of individuals. The total reported in the original article was maintained as 12.068 individuals. A minor one-unit discrepancy is observed when some family totals are summed directly from the table, probably due to the original tabulation.

Within Scarabaeidae, the most abundant species was *Ataenius aequalis* Harold, 1880, with 4,001 individuals, representing 81.9% of the scarabaeid beetles collected. Other Scarabaeidae included *Ateuchus striatulus* (Preudhomme de Borre, 1886) (371), *Aphodius lividus* Olivier, 1789 (328), *Digitonthophagus gazella* (Fabricius, 1787) (371) (73), *Euparia* sp. (45), *Aphodius* sp. (14), and other taxa with low abundance. The distribution of Scarabaeidae species differed significantly ($\chi^2 = 45059.08$; df = 14; $p < 0.0001$), showing strong dominance of *A. aequalis.*

Within Staphylinidae, *Oxytelus* sp. was the most abundant taxon, with 3,895 individuals, corresponding to 71.4% of the staphylinids collected. It was followed by *Philonthus* sp. (660), *Heterothops* sp. (415), and species 6 (188), while the remaining taxa occurred at lower frequencies. The abundance of Staphylinidae taxa differed significantly ($\chi^2 = 64226.49$; df = 23; $p < 0.0001$), indicating a highly uneven distribution within the family. Among Histeridae, species 1 was the most frequent taxon, with 492 individuals, followed by *Phelister* sp. (441), *Acritus* sp. (316), and species 3 (180). The remaining Histeridae taxa showed low frequencies. The distribution within Histeridae also differed significantly ($\chi^2 = 2098.24$; df = 8; $p < 0.0001$), demonstrating unequal representation of taxa in bovine feces (Figure 15).

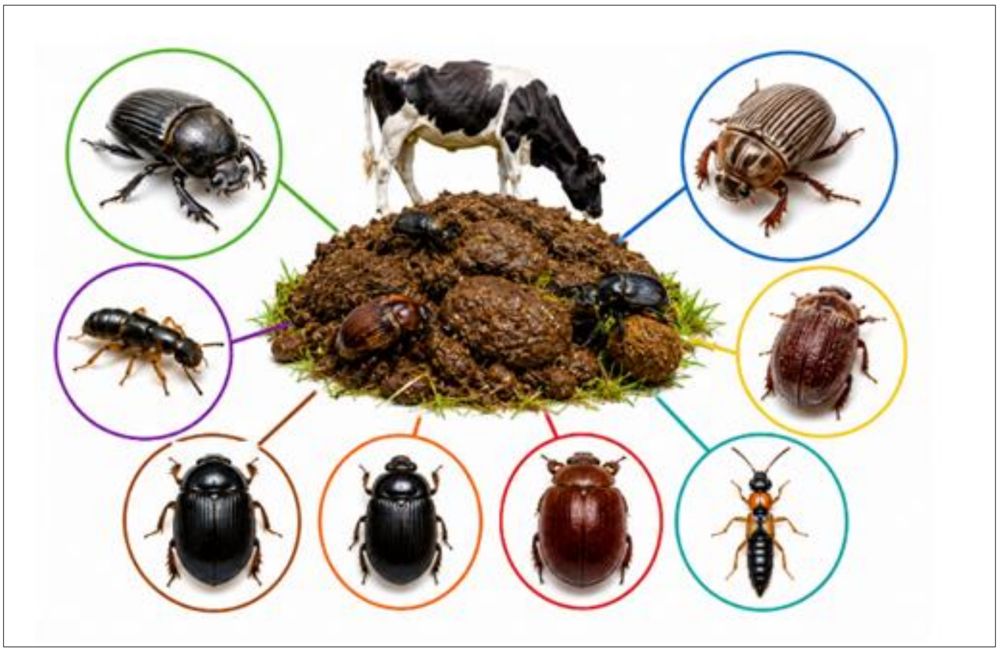

Figure 15: Survey of Coleoptera associated with cattle feces in the municipality of Itumbiara, Goiás, Brazil. The figure illustrates bovine feces as an ecological substrate for dung-associated beetles, highlighting the abundance and diversity of Coleoptera involved in decomposition, predation, and interactions with insects developing in cattle dung. The main beetle groups represented in the study were Histeridae, Scarabaeidae, and Staphylinidae

The results show that bovine feces supported a high abundance and diversity of Coleoptera in the studied area. The dominance of Staphylinidae and Scarabaeidae indicates that cattle dung serves as an important ecological substrate for beetles associated with decomposition, predation, and the biological regulation of dipteran populations. These groups are commonly associated with dung environments because they use fecal matter as a food resource, breeding site, or habitat for locating prey. The strong predominance of Staphylinidae was mainly due to the high abundance of *Oxytelus* sp., while the dominance of Scarabaeidae was largely explained by the high number of *A. aequalis*.

These taxa appear well adapted to bovine feces under the environmental conditions of Itumbiara. Their high abundance suggests that cattle dung may provide favorable conditions for development, feeding, and persistence in pasture environments. Histeridae also represented an important component of the beetle fauna, with several taxa recorded. Members of this family are frequently recognized as predators of immature Diptera and other small arthropods in decomposing substrates. Therefore, their occurrence in bovine feces may contribute to the natural regulation of fly populations, especially in livestock systems where synanthropic Diptera can be abundant.

The complementary chi-square analyses confirmed that the distribution of Coleoptera was not random among families or within the most abundant families. The significant results for Histeridae, Scarabaeidae, and Staphylinidae indicate strong dominance by a few taxa, while many others occurred at low frequencies. This pattern is common in dung-associated insect communities and may reflect differences in ecological specialization, competition, resource use, and tolerance to microclimatic conditions (Marchiori *et al.,* 2000a).

12. First Occurrence of *Muscidifurax Raptor* Girault & Sanders (Hymenoptera: Pteromalidae) in Pupae of *Palaeosepsis* Spp., and *M. Raptor* and *P. Vindemmiae* in Pupae of *S. Occidua* in Brazil

The two studies recorded pteromalid parasitoids associated with dipteran pupae collected from cattle dung in Itumbiara, Goiás, Brazil. In the first study, 593 pupae of *Palaeosepsis* spp. were obtained from cattle dung, from which 263 flies emerged, 324 pupae did not produce adults, and 6 parasitoids emerged. Among the parasitoids, four specimens of *M. raptor* were recorded, representing the first occurrence of this species in pupae of *Palaeosepsis* spp. in Brazil. The total parasitism rate was 1.0%, with *M. raptor* accounting for 0.67% and *Triplasta* sp. for 0.34%.

In the second study, 3.169 pupae of *S. occidua* were collected from cattle dung, from which 1.975 adult flies emerged, while 1.179 pupae did not produce adults. A total of 15 parasitoids emerged, corresponding to an overall parasitism rate of 0.47%. Among these parasitoids, four specimens of *M. raptor* and 11 specimens of *P. vindemmiae* were identified. This study reported the first occurrence of *M. raptor* and *P. vindemmiae* parasitizing pupae of *S. occidua* in cattle dung in Brazil. Considering both studies together, 3.762 dipteran pupae were examined, and 21 parasitoids emerged, resulting in a combined parasitism rate of approximately 0.56%.

Although the parasitism rates were low, the records are important because they expand the known host range of *M. raptor* and *P. vindemmiae* in Brazil. A comparison between parasitized and non-parasitized pupae showed a significant difference in both datasets, reflecting the predominance of non-parasitized pupae. For *Palaeosepsis* spp., the comparison was significant ($\chi^2 = 569.24$; df = 1; $p < 0.0001$), and for *S. occidua*, it was also significant ($\chi^2 = 3139.11$; df = 1; $p < 0.0001$). The combined results show that cattle dung can support the development of dipteran hosts and their associated parasitoids, although parasitism rates were low in both studies. The occurrence of *M. raptor* in pupae of *Palaeosepsis* spp. and *S. occidua* expands the known host associations of this parasitoid in Brazil. This is relevant because *M. raptor* is recognized as a pupal parasitoid of muscoid flies and may contribute to the natural regulation of Diptera populations in livestock environments (Figure 16).

Figure 16: Schematic representation of pteromalid parasitoids associated with dipteran pupae collected from cattle dung in Itumbiara, Goiás, Brazil. The figure illustrates cattle feces as the substrate, the presence of dipteran puparia, and the emergence of *M. raptor* and *P. vindemmiae*, emphasizing new host–parasitoid associations recorded in cattle-dung systems in Brazil

The record of *P. vindemmiae* in pupae of *S. occidua* also reinforces the ecological plasticity of this parasitoid. *P. vindemmiae* is considered a generalist pupal parasitoid, associated with several dipteran families and substrates. Its occurrence in cattle dung indicates that this substrate may function as an important ecological reservoir for parasitoids that attack synanthropic flies. Although the number of parasitoids obtained was small, both studies are important because they report new host–parasitoid associations. Low parasitism rates may be related to host availability, pupal location within the substrate, environmental conditions, sampling period, or competition with other organisms. The high number of pupae that did not produce adults also suggests that mortality may be influenced by factors other than parasitism, such as desiccation, predation, pathogens, or unsuitable developmental conditions (Marchiori *et al.,* 2000b; Marchiori *et al.,* 2001c).

13. Eucoilinae Collected in Lavras, Minas Gerais, Brazil

A total of 34 Eucoilinae specimens were collected in Lavras, Minas Gerais, Brazil, using a Malaise trap. The parasitoids belonged to seven taxa: *A. pelleranoi*, with 8 individuals; *Dettmeria* sp., with 4 individuals; *K. nigra*, with 2 individuals; *Odonteucoila* sp., with 1 individual; *P. egeria*, with 3 individuals; *Steleucoela* sp., with 14 individuals; and *Zaeucoila* sp., with 2 individuals. The most abundant was *Steleucoela* sp., representing 41.2% of the total collected specimens, followed by *A. pelleranoi*, with 23.5%.

The least frequent taxon was *Odonteucoila* sp., with 2.9%. The article reports these same values. The abundance of Eucoilinae taxa differed significantly ($\chi^2 = 26.53$; df = 6; $p = 0.0002$), indicating that the specimens were not equally distributed among taxa. The predominance of *Steleucoela* sp. suggests that this genus was better represented in the sampled area, possibly due to local host availability, vegetation structure, and environmental conditions associated with the forest fragment sampled by the Malaise trap (Figure 17).

Figure 17: Schematic representation of Eucoilinae parasitoids collected with a Malaise trap in Lavras, Minas Gerais, Brazil. The figure illustrates the trap installed in a forested environment and the capture of parasitoid Hymenoptera, emphasizing the diversity of Eucoilinae recorded in the sampled area and the predominance of *Steleucoela* sp. among the collected taxa

The results show that the Eucoilinae assemblage collected in Lavras was composed of a few individuals but included several taxa, indicating local diversity within this parasitoid group. The dominance of *Steleucoela* sp. was evident, representing more than 40% of the specimens collected. This predominance suggests that the genus may be more adapted to the sampled environment or may have had greater host availability during the collection period. The significant chi-square result confirms that Eucoilinae taxa were not evenly represented. Some taxa, such as *A. pelleranoin* and *Steleucoela* sp., were more frequent, whereas others, such as *K. nigra*, *Odonteucoila* sp., and *Zaeucoila* sp., were recorded in low numbers.

This uneven distribution may reflect differences in host specificity, habitat preference, seasonal activity, or sampling efficiency of the Malaise trap. The record of *A. pelleranoi* is relevant because this species is commonly associated with larvae of frugivorous Diptera and has importance as a natural enemy in fruit-based systems. The occurrence of *K. nigra*, *P. egeria*, and other Eucoilinae taxa also reinforces the ecological role of Figitidae as parasitoids of Diptera. Even with a small sample size, the study contributes to the knowledge of Eucoilinae diversity and distribution in Minas Gerais. Overall, the findings indicate that forested or semi-natural areas can maintain representative assemblages of Eucoilinae parasitoids. These environments may act as reservoirs of natural enemies and contribute to the maintenance of parasitoid diversity in agricultural landscapes (Silva *et al.,* 2003).

14. First Report of *B. Podagrica* Parasitizing *Squamatoides Trivittatus* Curran, 1927 (Diptera: Sarcophagidae) in Brazil

A total of 50 pupae of *S. trivittatus* were obtained from bovine kidney substrate in Lavras, Minas Gerais, Brazil. From these pupae, two specimens of *B. podagrica* emerged, resulting in a parasitism rate of 4.0%. This record represents the first report of *B. podagrica* parasitizing pupae of *S. trivittatus* in Brazil. The article reports the same values, with 50 pupae obtained, 48 flies emerging, and two parasitoids identified as *B. podagrica*. Because only one parasitoid species was recorded, comparison among parasitoid taxa was not applicable.

However, when parasitized and non-parasitized pupae were compared, the difference was significant ($\chi^2 = 42.32$; df = 1; $p < 0.0001$), with 2 parasitized pupae and 48 non-parasitized pupae. This result indicates that most pupae were not parasitized, although the occurrence of *B. podagrica* confirms its association with *S. trivittatus* under the sampled conditions (Figures 18-19) (Barros *et al.*, 2006).

Figure 18: *Brachymeria podagrica* is relevant because new host records help clarify the host range, distribution, and potential biological control importance of parasitoids associated with flies of sanitary and veterinary interest. Source: Photo#552824/ Graham Montgomery/Iowa State University

Figure 19: (1) *Squamatoides trivittatus* on the mouth opening of a *Sus scrofa* carcass. (2) Adult male of *S. trivittatus*. This species exhibits a high degree of synanthropy and may act as a potential mechanical vector of enteropathogenic agents. Source: Barros, R. M. *et al.* (2006)

The occurrence of *B. podagrica* in pupae of *S. trivittatus* expands the knowledge of host–parasitoid associations involving sarcophagid flies in Brazil. Although the parasitism rate was low, at 4.0%, this record is important because it represents the first report of this parasitoid using *S. trivittatus* as a host in the country. The low parasitism rate may be related to host availability, substrate conditions, sampling period, or the ability of the parasitoid to locate pupae in the bovine kidney substrate. Even with only two parasitoids recovered, the record reinforces the ecological plasticity of *B. podagrica*, a parasitoid previously associated with several synanthropic Diptera.

The significant chi-square result reflects the predominance of non-parasitized pupae in the sample. However, from an ecological perspective, the detection of *B. podagrica* is relevant because new host records help clarify the host range, distribution, and potential biological control importance of parasitoids associated with flies of sanitary and veterinary interest (Silva *et al.*, 2005).

15. Parasitoids of the Family Pteromalidae (Hymenoptera) Collected from Cattle Feces on a Rural Property in the Municipality of Panamá, Goiás, Brazil

A total of 293 dipteran pupae were collected from cattle dung in Panamá, Goiás, Brazil. Of these, 43 pupae were parasitized, resulting in an overall parasitism rate of 14.7%. The hosts recorded were *A. scabra* (27 pupae), *B. debilis* (52), *B. quadristigma* (31), *C. pararescita* (50), *M. domestica* (10), *Palaeosepsis* spp. (60), and *R. belforti* (63). Host abundance differed significantly among dipteran species ($\chi^2 = 54.92$; df = 6; $p < 0.0001$), indicating that pupae were not equally distributed among hosts. The article reports the same total of 293 pupae, 43 parasitized pupae, and 14.7% overall parasitism rate.

The parasitoids recorded were *P. vindemmiae, S. cameroni, S. drosophilae, S. endius, S. nigra*, and *S. nigroaenea*. The most frequent species was *S. nigroaenea*, with 18 individuals (41.9%), followed by *S. drosophilae* and *S. nigra*, each with 7 individuals (16.3%), *P. vindemmiae* with 5 individuals (11.6%), *S. cameroni* with 4 individuals (9.3%), and *S. endius* with 2 individuals (4.7%). The abundance of parasitoid species differed significantly ($\chi^2 = 22.16$; df = 5; p = 0.0005), showing that parasitoid occurrence was not evenly distributed among taxa (Table 14).

Table 14: Pteromalidae parasitoids collected from cattle dung in Panamá, Goiás, Brazil

Host species	Pupae collected	Parasitoid species	Parasitized pupae	Frequency (%)
Archisepsis scabra	27	*Spalangia drosophilae*	4	14.81
Brontaea debilis	52	*Spalangia cameroni*	1	1.92
		Spalangia nigroaenea	2	3.85
Brontaea quadristigma	31	*Spalangia cameroni*	1	3.23
		Spalangia drosophilae	1	3.23
		Spalangia endius	1	3.23
		Spalangia nigroaenea	5	16.10
Cyrtoneurina pararescita	50	*Spalangia nigra*	3	6.00
		Spalangia nigroaenea	5	10.00
Musca domestica	10	*Spalangia cameroni*	1	10.00
Palaeosepsis spp.	60	*Spalangia drosophilae*	2	3.33
		Spalangia endius	1	1.67
Ravinia belforti	63	*Pachycrepoideus vindemmiae*	5	7.94
		Spalangia cameroni	1	1.59
		Spalangia nigra	4	6.35
		Spalangia nigroaenea	6	9.52
Total	**293**		**43**	**14.7**

Note: Overall parasitism = 43/293 = 14.7%.

Parasitism also differed significantly among host species ($\chi^2 = 16.88$; df = 6; p = 0.0098). The highest number of parasitized pupae was recorded in *R. belforti* (16 pupae), followed by *B. quadristigma* and *C. pararescita* (8 pupae each), *A. scabra* (4), *B. debilis,* and *Palaeosepsis* sp. (3 each), and *M. domestica* (1). Host–parasitoid association was significant ($\chi^2 = 66.71$; df = 30; p = 0.0001), confirming that parasitoids were not randomly distributed among host species. This agrees with the original article, which reported significant host preference among parasitoids ($\chi^2 = 66.17$; df = 30; $p < 0.05$).

The results show that cattle dung in Panamá, Goiás, supported a diverse assemblage of Pteromalidae parasitoids associated with dipteran pupae. Although the total number of pupae collected was moderate, the parasitism rate of 14.7% indicates relevant natural parasitoid activity in this substrate. The presence of several hosts and parasitoid species suggests that cattle dung provides suitable conditions for the development of synanthropic flies and their natural enemies.

The significant difference in host abundance indicates that some dipteran species were more strongly associated with cattle dung than others. *B. debilis*, *C. pararescita, Palaeosepsis* spp., and *R. belforti* were among the most abundant hosts, suggesting that substrate quality, moisture, exposure time, and microhabitat conditions may have influenced pupal development. Host availability is an important factor because parasitoid occurrence depends directly on the presence and suitability of host pupae. Among the parasitoids, *S. nigroaenea* was the dominant species, representing more than 40% of all parasitoids obtained. The significant chi-square result for parasitoid abundance confirms that the parasitoid community was unevenly structured, with a few species occurring more frequently than others.

The occurrence of *P. vindemmiae, S. cameroni*, *S. drosophilae*, *S. endius*, and *S. nigra* also reinforces the importance of Pteromalidae as natural enemies of dung-breeding Diptera. The significant host–parasitoid association indicates that parasitoid species did not use hosts randomly. *Pachycrepoideus vindemmiae* was recorded in *R. belforti*, while species of *Spalangia* were associated with different hosts, including *A. scabra*, *B. debilis*, *B. quadristigma*, *C. pararescita*, *M. domestica*, *Palaeosepsis* spp., and *R. belforti*. These associations suggest differences in host suitability, host location behavior, and parasitoid adaptation to pupae developing in cattle dung (Marchiori *et al.,* 2005c) (Figure 20).

Figure 20: Schematic representation of Pteromalidae parasitoids associated with dipteran pupae collected from cattle feces on a rural property in Panamá, Goiás, Brazil. The figure illustrates cattle dung as a substrate for dipteran development, the presence of puparia, and the emergence of pteromalid parasitoids, emphasizing the diversity of host–parasitoid associations recorded in this system

16. *Gnathopleura Quadridentata* as a Natural Enemy of *S. Lambens* in Brazil

A total of 50 pupae of *S. lambens* were collected from human feces in Caldas Novas, Goiás, Brazil. From these pupae, 28 specimens of *G. quadridentata* emerged, resulting in a parasitism rate of 56.0%. This record represents the first occurrence of *G. quadridentata* parasitizing pupae of *S. lambens* in Brazil. The article reports that the pupae were obtained using dark-colored cans baited with human feces and that the pupae were individualized in gelatin capsules until the emergence of flies or parasitoids.

Because only one parasitoid species was recorded, comparison among parasitoid taxa was not applicable. When parasitized and non-parasitized pupae were compared, the difference was not statistically significant ($\chi^2 = 0.72$; df = 1; $p = 0.3961$), with 28 parasitized pupae and 22 non-parasitized pupae. However, the parasitism rate of 56.0% indicates a high level of natural parasitism of *S. lambens* by *G. quadridentata* under the sampled conditions (Figure 21).

Figure 21: *Gnathopleura quadridentata* associated with dipteran pupae collected in decomposing organic substrates in Brazil. This parasitoid record is biologically relevant because more than half of the recovered pupae produced parasitoids, indicating a strong host–parasitoid association under the sampled conditions. The occurrence of *G. quadridentata* reinforces the importance of braconid parasitoids as natural enemies of synanthropic Diptera. Sources: http://www.biovirtual.unal.edu.co/Alysiinae/Gnatholeura%20cf.quadridentata.html/Universidad Nacional de Colombia

The occurrence of *G. quadridentata* in pupae of *S. lambens* expands the knowledge of host–parasitoid associations involving sarcophagid flies in Brazil. The parasitism rate of 56.0% was high, indicating that this parasitoid may be an important natural enemy of *S. lambens* in environments associated with human feces and decomposing organic matter. Although the chi-square comparison between parasitized and non-parasitized pupae was not significant, the biological relevance of the record remains important because more than half of the pupae produced parasitoids. This suggests that *G. quadridentata* was able to locate and successfully parasitize *S. lambens* pupae in the sampled substrate. The use of human feces as bait also reinforces the importance of synanthropic substrates in studies of Diptera and their parasitoids (Marchiori and Silva Filho, 2006c).

17. Families of Parasitoids (Hymenoptera) Collected in the South of Goiás, Brazil

A total of 6.377 parasitoid Hymenoptera specimens were collected in southern Goiás, Brazil, between February and October 2002, using two sampling methods. Of these, 2.242 specimens (35.2%) were collected using yellow pan traps, whereas 4.135 specimens (64.8%) were collected using Malaise traps. The difference between trap types was statistically significant (χ^2 = 561.70; df = 1; $p < 0.0001$), indicating that Malaise traps collected significantly more parasitoids than yellow pan traps. In yellow pan traps, the most abundant families were Ichneumonidae, with 441 specimens (19.7%), Encyrtidae, with 370 (16.5%), Diapriidae, with 350 (15.6%), Braconidae, with 229 (10.2%), and Bethylidae, with 221 (9.9%). The distribution of parasitoid families in yellow pan traps differed significantly (χ^2 = 1594.36; df = 20; $p < 0.0001$), showing that the families were not equally represented (Table 15).

Table 15: Families of parasitoids collected in yellow pan traps in southern Goiás, Brazil, from February to October 2002

Taxonomic group	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.
Bethylidoidea:									
Bethylidae	46	28	13	35	13	14	25	31	16
Dryinidae	1	1	0	2	0	0	0	1	1
Ceraphronidae:									
Ceraphronidae	16	20	31	13	2	2	5	9	1
Megaspilidae	1	1	0	2	1	0	12	2	0
Chalcidoidea:									
Agaonidae	1	0	0	1	0	0	0	0	0
Chalcididae	1	1	7	5	0	3	3	15	2
Encyrtidae	118	31	24	89	35	40	13	17	3
Eucharitidae	0	4	1	3	1	2	3	1	0
Eulophidae	16	8	16	34	5	8	7	10	15
Eupelmidae	6	1	4	2	3	3	13	26	13
Eurytomidae	1	0	0	0	2	3	2	0	1
Mymaridae	1	1	0	2	1	0	11	2	0
Pteromalidae	9	0	2	12	3	8	3	0	1
Torymidae	20	4	3	13	3	6	4	0	0
Cynipoidea:									
Figitidae	12	15	12	3	2	0	0	3	4
Evanioidea:									
Evaniidae	3	0	2	2	0	0	3	7	3
Ichneumonoidea:									
Braconidae	113	25	33	18	9	6	9	12	4
Ichneumonidae	118	67	87	42	8	4	33	61	21
Platygastroidea:									
Platygastridae	4	0	2	8	4	3	12	1	1
Scelionidae	14	2	4	13	5	9	1	0	1
Proctotrupoidea:									
Diapriidae	106	12	65	50	22	18	19	48	10

In Malaise traps, Ichneumonidae was also the most abundant family, with 1,546 specimens (37.4%), followed by Bethylidae, with 534 (12.9%), Braconidae, with 806 (19.5%), Chalcididae, with 432 (10.4%), and Figitidae, with 137 (3.3%). The distribution of parasitoid families in Malaise traps also differed significantly (χ^2 = 8632.44; df = 20; $p < 0.0001$), indicating strong dominance of a few families. Comparison between trap types also showed significant differences in family composition (χ^2 = 1208.53; df = 20; $p < 0.0001$), indicating that trap type strongly influenced the assemblage of parasitoid families collected. Families such as Bethylidae, Braconidae, Chalcididae, and Ichneumonidae were more abundant in Malaise traps, whereas some groups showed relatively greater proportional representation in yellow pan traps (Figure 22) (Table 16).

Figure 22: Schematic representation of parasitoid Hymenoptera families collected in southern Goiás, Brazil, using yellow pan traps and Malaise traps. The figure illustrates the two sampling methods and the diversity of parasitoids captured, emphasizing the greater capture efficiency of Malaise traps and the complementary role of yellow pan traps in sampling parasitoid families

Table 16: Families of parasitoids collected in Malaise traps in southern Goiás, Brazil, from February to October 2002

Taxonomic group	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**	**Oct.**
Bethylidoidea:									
Bethylidae	90	55	36	91	34	52	58	63	55
Dryinidae	4	4	1	1	1	1	2	1	1
Ceraphronidae:									
Ceraphronidae	1	1	1	0	0	0	0	0	0
Megaspilidae	2	1	1	0	0	3	1	0	2
Chalcidoidea:									
Agaonidae	0	0	5	1	0	0	0	0	0
Chalcididae	53	33	52	62	21	25	29	75	82
Encyrtidae	41	21	25	14	10	5	2	4	2
Eucharitidae	1	3	1	3	0	1	0	4	6
Eulophidae	19	36	46	18	2	8	11	29	1
Eupelmidae	13	10	8	21	9	12	11	11	10
Eurytomidae	0	1	1	2	5	0	1	3	5
Mymaridae	0	1	0	0	0	3	1	0	1
Pteromalidae	3	1	3	1	1	1	1	1	0
Torymidae	2	2	2	1	1	1	2	0	1
Cynipoidea:									
Figitidae	39	45	32	7	4	1	4	5	0
Evanioidea:									
Evaniidae	5	4	13	16	3	2	1	8	67
Ichneumonoidea:									
Braconidae	249	162	116	81	34	23	44	45	52
Ichneumonidae	408	422	293	149	103	63	39	69	0
Platygastroidea:									
Platygastridae	2	1	1	1	1	3	0	1	1
Scelionidae	3	2	3	1	2	1	1	1	0
Proctotrupoidea:									
Diapriidae	9	6	6	2	3	2	3	3	1

The results demonstrate that both yellow pan traps and Malaise traps were effective in collecting parasitoid Hymenoptera in southern Goiás, but the efficiency of the methods differed substantially. Malaise traps captured nearly twice as many specimens as yellow pan traps, suggesting greater effectiveness for sampling flying parasitoid communities in forest and pasture environments. The predominance of Ichneumonidae in both trap types indicates that this family was a major component of the parasitoid fauna in the sampled region.

This result is ecologically consistent because ichneumonids are highly diverse parasitoids associated with a wide range of insect hosts. Their high abundance in Malaise traps likely reflects the suitability of this trap design for intercepting active flying parasitoids. The significant chi-square analyses confirm that parasitoid communities were not randomly distributed among families and that trap type strongly influenced capture patterns. Yellow pan traps, which rely on visual attraction and passive capture, may preferentially collect taxa responsive to color stimuli or low-level flight activity. In contrast, Malaise traps intercept flying insects moving through the environment and therefore tend to be more efficient for sampling mobile parasitoids.

The higher abundance of Bethylidae, Braconidae, Chalcididae, and Ichneumonidae in Malaise traps suggests that these groups are more actively dispersed through vegetation strata. Conversely, yellow pan traps may provide complementary sampling for groups less effectively intercepted by flight barriers. The significant differences in family composition reinforce the importance of combining sampling methods when evaluating parasitoid biodiversity (Marchiori, 2014a).

18. Microhymenoptera Eucoilinae Parasitizing Dipteran Species That Develop in Cattle Feces in Panama, Goiás State, Brazil

A total of 293 dipteran pupae were collected from cattle dung in Panamá, Goiás, Brazil. Of these, 14 pupae were parasitized by four Eucoilinae taxa, resulting in an overall parasitism rate of 4.78%. The host species recorded were *A. scabra* (27 pupae), *B. debilis* (52), *B. quadristigma* (31), *C. pararescita* (50), *M. domestica* (10), *Palaeosepsis* spp. (60), and *R. belforti* (63). Host abundance differed significantly among dipteran species ($\chi^2 = 54.92$; df = 6; $p < 0.0001$), indicating that pupae were not evenly distributed among hosts.

The parasitoids recorded were *K. nigra, P. egeria, T. atrocoxalis*, and *T. coxalis. Kleidotoma nigra* emerged from pupae of *B. quadristigma*, with two emerged parasitoids and a parasitism frequency of 6.45%. *Paraganaspis egeria* and *T. atrocoxalis* each emerged from *Palaeosepsis* spp., with two individuals and 3.33% parasitism each. *Triplasta coxalis* was the most frequent parasitoid, with eight emerged individuals, corresponding to 57.14% of the Eucoilinae obtained and 13.33% parasitism in *Palaeosepsis* spp. (Table 17).

Table 17: Eucoilinae parasitoids emerged from Diptera pupae collected in cattle dung in Panamá, Goiás, Brazil

Host species	Number of pupae	Parasitoid species	Number of emerged parasitoids	Number of parasitized pupae	Parasitism rate (%)
Archisepsis scabra	27	Absent	—	—	—
Brontaea debilis	52	Absent	—	—	—
Brontaea quadristigma	31	*Kleidotoma nigra*	2	2	6.45
Cyrtoneurina pararescita	50	Absent	—	—	—
Musca domestica	10	Absent	—	—	—
Palaeosepsis spp.	60	*Paraganaspis egeria*	2	2	3.33
		Triplasta atrocoxalis	2	2	3.33
		Triplasta coxalis	8	8	13.33
Ravinia belforti	63	Absent	—	—	—
Total pupae: 293		**14**	**14**	**4.78**	

The abundance of Eucoilinae taxa did not differ significantly when compared among the four parasitoid taxa ($\chi^2 = 7.71$; df = 3; p = 0.0523), although *T. coxalis* was numerically dominant. However, the distribution of parasitized and non-parasitized pupae differed significantly among host species ($\chi^2 = 40.88$; df = 6; $p < 0.0001$), showing that parasitism was concentrated in specific hosts. The original study also reported a significant host preference among parasitoids ($\chi^2 = 14.00$; df = 3; $p < 0.05$), indicating that *K. nigra* was associated with *B. quadristigma*, whereas *P. egeria*, *T. atrocoxalis*, and *T. coxalis* were associated with *Palaeosepsis* spp. The results show that cattle dung in Panamá, Goiás, supported Eucoilinae parasitoids associated with dipteran pupae, although the overall parasitism rate was relatively low. The occurrence of four Eucoilinae taxa indicates that cattle dung is an important substrate for maintaining parasitoids that exploit Diptera developing in decomposing organic matter.

Parasitism was not evenly distributed among hosts. Most parasitized pupae occurred in *Palaeosepsis* spp., which were attacked by *P. egeria*, *T. atrocoxalis*, and *T. coxalis*. In contrast, *K. nigra* was recorded only in *B. quadristigma*. This pattern suggests that host identity, host suitability, and pupal microhabitat may strongly influence parasitoid occurrence and host use. The numerical predominance of *T. coxalis* suggests greater success of this parasitoid in the sampled conditions.

Although the chi-square comparison among parasitoid taxa was marginally non-significant, the biological pattern is relevant because *T. coxalis* represented more than half of the Eucoilinae recovered (Figure 23) (van Noort, 2026).

Figure 23: Eucoilinae parasitoids (Hymenoptera: Figitidae) associated with immature stages of cyclorrhaphous Diptera in decomposing organic substrates. Members of this subfamily are mainly endoparasitoids of fly larvae, completing their development inside the host and emerging from the puparium. This group is ecologically important because it contributes to the natural regulation of Diptera populations in feces, carcasses, fruits, and other organic substrates. Source: Simon van Noort (Iziko South African Museum)

This may be related to its search capacity, local population density, or adaptation to *Palaeosepsis* spp. pupae in cattle dung. The significant host-preference result reported in the original study reinforces that parasitoids did not exploit hosts randomly. Such host associations are important for understanding the structure of parasitoid communities and their potential contribution to the natural regulation of dung-breeding Diptera (Marchiori *et al.,* 2004).

19. Arthropoda Associated with Pig Carcasses in Itumbiara, southern Goiás

Trichillum externepunctatum was the most abundant species, with 300 individuals (57.0%). Scarabaeidae was the dominant family, with 467 individuals (88.8%). A greater number of individuals and species were obtained in the forest, probably due to higher humidity during December, which may have favored carcass decomposition and Coleoptera development (Table 18).

Table 18: Abundance and relative frequency of Coleoptera collected from pig carcasses in Goiás, Brazil

Taxonomic group	**Species of morpho-species**	**Number individuals**	**Frequency (%)**
Carabidae	Carabidae sp.1	5	1.0
Chrysomelidae	Chrysomelidae sp.1	2	0.4
Dermestidae	Dermestidae sp.1	5	1.0
Histeridae	Histeridae sp.1	1	0.2
	Histeridae sp.2	2	0.4
	Histeridae sp.3	1	0.2
	Histeridae sp.4	1	0.2
	Histeridae sp.5	1	0.2
	Total	**6**	**1.1**
Scarabaeidae	*Anomiopus* sp.	10	1.9
	Ataenius sp.1	100	19.0
	Ataenius sp.2	05	1.0
	Chaetodus sp.	23	4.4
	Dichotomius sp.	09	1.7
	Phyllophaga sp.	20	3.8
	Trichillum externepunctatum	300	57.0
	Total	**467**	**88.8**
Staphylinidae	Staphylinidae sp.1	5	1.0
	Staphylinidae sp.2	6	1.1
	Total	11	2.1
Trogidae:	*Omorgus suberosus*	30	5.7
Total geral		**526**	**100.0**

Regarding abiotic factors related to carcass decomposition, relative humidity appeared to have a strong influence on the decomposition process. Based on Table 19, carcass decomposition took longer in October, when precipitation was lower, requiring 25 days, whereas in December, under higher precipitation, decomposition lasted only 9 days. In contrast, temperature did not appear to be a determining factor in carcass degradation, because similar average temperatures were recorded in both months. For Coleoptera only, the chi-square analysis showed a significant difference in abundance among families (χ^2 = 2391.11; df = 6; p < 0.0001), with strong predominance of Scarabaeidae. The distribution among morphospecies was also significant (χ^2 = 2969.90; df = 17; p < 0.0001), mainly due to the dominance of *T. externepunctatum*. (Table 19).

Table 19: Climatic data recorded at the Faculty of Agronomy Farm in Itumbiara, Goiás, Brazil

Month	Average temperature (°C)	Precipitation (mm)	Local (environment)
October	26.4	61.6	Pasture
December	26.3	267.3	Forest

The higher abundance and richness observed in the forest area may be related to increased humidity and precipitation, which can accelerate carcass decomposition and favor the activity of Coleoptera associated with carrion. These environmental conditions may influence both the speed of decomposition and the availability of resources for necrophagous and predatory beetles. Knowledge of the insect fauna associated with animal carcass decomposition, together with climatic conditions, is important because these data can be applied in forensic investigations to support the interpretation of decomposition processes and the estimation of the postmortem interval (Figure 24) (Marchiori *et al.,* 2000c).

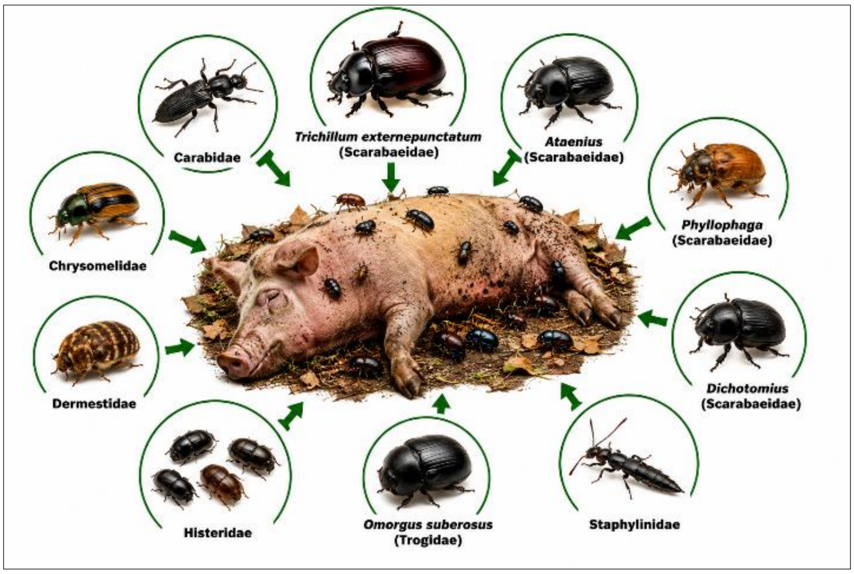

Figure 24: Schematic representation of arthropods, especially Coleoptera, associated with pig carcasses in Itumbiara, southern Goiás, Brazil. The figure illustrates the carcass as a decomposition substrate and the main beetle groups recorded during decomposition, emphasizing the predominance of Scarabaeidae and the high abundance of *T. externepunctatum*. The assemblage also included representatives of Carabidae, Chrysomelidae, Dermestidae, Histeridae, Staphylinidae, and Trogidae, highlighting the ecological importance of carrion-associated arthropods in decomposition and forensic studies

20. First Occurrence of *Necrobia Rufipes* (De Geer) (Coleoptera: Cleridae) in Dipteran Pupae in Brazil

A total of 303 pupae of *P. chrysostoma* were collected using traps baited with fish in a forest area near Parque Estadual da Serra de Caldas Novas, Goiás, Brazil, from August to November 2003. After dissection of non-emerged pupae, two living specimens of *N. rufipes* were obtained, corresponding to an occurrence rate of 0.66%. This record represents the first occurrence of *N. rufipes* associated with dipteran pupae in Brazil. The article reports that the beetles were obtained from immature stages of *P. chrysostoma* and suggests that larvae of *N. rufipes* may have penetrated small openings in the pupae, using them as food during development.

Because only one coleopteran species was recorded, comparison among taxa was not applicable. However, when pupae with and without *N. rufipes* were compared, the difference was significant (χ^2 = 295.05; df = 1; p < 0.0001), with 2 pupae associated with *N. rufipes* and 301 pupae without this association. This result indicates that the occurrence was rare in the sampled material, although biologically important because it represents a new record (Figure 25).

Figure 25: Unusual occurrence of *N. rufipes* associated with dipteran puparia obtained from decomposing swine organic material. The figure illustrates the sequence from decomposing substrate to laboratory examination of non-emerged puparia, showing live adult beetles recovered after the puparia were opened. This rare observation suggests the possible entry of beetle larvae into recently formed puparia before adult emergence

The occurrence of *N. rufipes* in pupae of *P. chrysostoma* expands the knowledge of insect associations involving carrion-related Diptera in Brazil. Although the frequency was low, this record is relevant because *N. rufipes* is commonly associated with animal carcasses, decomposing organic matter, and forensic environments. Its presence in dipteran pupae suggests that this beetle may interact with immature stages of flies not only as a scavenger but also potentially as a predator or opportunistic feeder. The low occurrence rate of 0.66% indicates that the association between *N. rufipes* and *P. chrysostoma* pupae was uncommon under the sampled conditions.

However, the biological significance of the finding is high because it represents the first report of this beetle associated with fly pupae in Brazil. This type of record contributes to the understanding of ecological interactions in decomposition environments and may be useful in forensic entomology. The significant chi-square result reflects the strong predominance of pupae without *N. rufipes*. Nevertheless, rare records should not be disregarded, especially when they indicate new ecological interactions. The presence of *N. rufipes* in pupae of *P. chrysostoma* suggests that further studies are necessary to determine whether this association is accidental or part of a broader ecological strategy during carcass decomposition (Marchiori, 2021).

21. Succession of Scarabaeidae on bovine dung in Itumbiara, Goiás, Brazil

A total of 3.229 Scarabaeidae specimens were collected from bovine dung exposed in pasture in Itumbiara, Goiás, Brazil, between January and October 2001. Eleven taxa were identified. The most abundant species was *A. aequalis*, with 2.206 individuals (68.4%), followed by *A. lividus,* with 344 individuals (10.7%), and *D. gazella*, with 297 individuals (9.3%). The remaining species occurred at lower frequencies: *Aphodius* sp. 2 (77; 2.5%), *Aphodius* sp.1 (74; 2.4%), *Dromius negrita* Wollaston, 1854 (63; 2.0%), *Onthophagus hircus* Billberg, 1815 (39; 1.3%), *T. externepunctatum* (37; 1.1%), *Canthon lituratus* (Germar, 1813 (16; 0.5%), *Ataenius viridis* Harold, 1867 (13; 0.5%), *D. bos* (30; 0.9%), *Euparia* sp. (2; 0.1%), and *Onthophagus ranunculus,* Arrow, 1913 (4; 0.1%) (Table 20).

Table 20: Number and relative frequency of Scarabaeidae species collected from bovine dung in Itumbiara, Goiás, Brazil

Scarabaeidae species	Total number/species	Frequency (%)
Ataenius viridis	13	0.4
Aphodius sp.1	74	2.3
Aphodius sp.2	77	2.4
Ataenius nigrita	63	2.0
Aphodius lividus	344	10.7
Ataenius sp.1	27	0.8
Ataenius aequalis	2206	68.3
Canthon lituratus	16	0.5
Dichotomius bos	30	0.9
Dichotomius gazella	297	9.2
Euparia sp.	2	0.1
Onthophagus hircus	39	1.2
Onthophagus ranunculus	4	0.1
Trichillum externepunctatum	37	1.1
Total	**3229**	**100.0**

The distribution of Scarabaeidae species differed significantly ($\chi^2 = 13{,}182.44$; df = 12; $p < 0.0001$), indicating strong dominance by a few taxa, especially *A. aequalis*. Regarding exposure time, the highest abundance was observed in dung exposed for 48 hours (524 individuals), followed by 24 hours (552 individuals), 192 hours (320 individuals), and 96 hours (282 individuals). Lower abundances were recorded at later stages, with 244 individuals at 240 hours. The abundance of Scarabaeidae differed significantly among exposure periods ($\chi^2 = 332.17$; df = 9; $p < 0.0001$), showing that beetle succession changed over decomposition time (Table 21).

Table 21: Number of Scarabaeidae specimens collected after different exposure times of bovine dung in Itumbiara, Goiás, Brazil

Taxonomic group	24h.	48h.	72h.	96h.	120h.	144h.	168h.	192h.	216h.	240h.	Total
Ataenius viridis	6	4	2	0	0	0	0	0	0	1	13
Aphodius sp.1	58	12	0	0	0	0	2	0	0	2	74
Aphodius sp.2	57	16	0	0	0	0	3	0	0	1	77
Ataenius nigrita	11	13	15	18	1	1	0	2	0	2	63
Aphodius lividus	115	93	26	7	48	5	3	21	25	1	344
Ataenius sp.1	0	0	0	1	5	1	18	2	0	0	27
Ataenius aequalis	121	266	182	224	192	232	216	287	259	227	2206
Canthon lituratus	10	6	0	0	0	0	0	0	0	0	16
Dichotomius bos	10	3	7	1	1	2	2	1	0	3	30
Dichotomius gazella	123	64	61	31	10	4	0	3	0	1	297
Euparia sp.	0	0	0	0	2	0	0	0	0	0	2
Onthophagus hircus	11	10	3	0	2	2	1	4	0	6	39
Onthophagus ranunculus	4	0	0	0	0	0	0	0	0	0	4
Trichillum externepunctatum	26	7	4	0	0	0	0	0	0	0	37
Total	**552**	**494**	**300**	**282**	**261**	**247**	**245**	**320**	**284**	**244**	**3.229**

Species preference for exposure period was also significant, as reported in the original study ($\chi^2 = 1421.26$; df = 99; $p < 0.0001$). *A. aequalis* and *A. lividus* predominated in fresh dung (one to two days), while D. bos and D. gazella were more associated with dung exposed for intermediate periods. *T. externepunctatum* showed greater occurrence in dung exposed for one to three days (Figure 26) (Table 22).

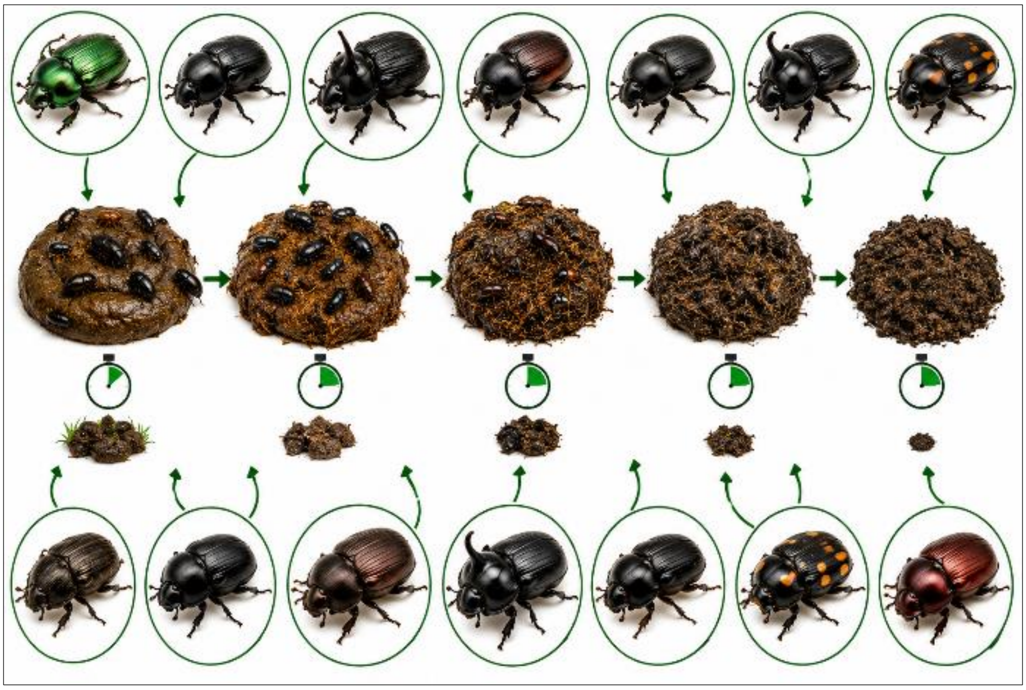

Figure 26: Schematic representation of Scarabaeidae succession on bovine dung exposed in pasture in Itumbiara, Goiás, Brazil. The figure illustrates progressive dung decomposition and colonization by dung beetles over exposure time, emphasizing temporal changes in abundance and species composition. The assemblage was strongly dominated by *A. aequalis*

Table 22: Faunal indices of Scarabaeidae species collected from bovine dung in Itumbiara, Goiás, Brazil

Scarabaeidae species	C¹	D²	F	AB
Aphodius sp.1	Z	ND	Lf	C
Aphodius sp.2	Z	ND	Lf	C
Ataenius nigrita	Z	ND	Lf	D
Aphodius lividus	X	ND	F	A
Ataenius viridis	Z	ND	Lf	D
Ataenius sp.1	Z	ND	Lf	D
Ataenius aequalis	X	D	Vf	Sa
Canthon lituratus	Z	ND	Lf	D
Dichotomius bos	Z	ND	Lf	D
Dichotomius gazella	Y	ND	F	Va
Euparia sp.	Z	ND	Lf	R
Onthophagus hircus	Y	ND	Lf	D
Onthophagus ranunculus	Z	ND	Lf	R
Trichillum externepunctatum	Z	ND	Lf	C

Note: C¹ = constancy: X, present in more than 50% of samplings; Y, present from 25% to 50%; Z, present in less than 25%. D² = dominance: D, dominant; ND, non-dominant. F = frequency: lf, little frequent; f, frequent; vf, very frequent. AB = abundance: r, rare; d, disperse; c, common; a, abundant; va, very abundant; sa, super-abundant.

Faunistic indices showed that 78.6% of species belonged to the dominant category, while 42.9% were classified as abundant. *A. aequalis* was classified as constant, dominant, very frequent, very abundant, and present in fresh dung, confirming its ecological importance in bovine dung decomposition. The results demonstrate that Scarabaeidae beetles were highly abundant in bovine dung in pasture environments in Itumbiara, Goiás, with more than three thousand specimens collected.

The marked predominance of *A. aequalis* indicates that this species was the principal component of the dung beetle community, likely due to its high adaptation to cattle dung as a feeding and reproductive resource. The significant chi-square result for species abundance confirms that the Scarabaeidae community was highly uneven, with a few dominant species accounting for most individuals. This pattern is typical of dung beetle communities, in which environmental conditions, resource quality, and interspecific competition favor certain taxa over others.

The significant differences among exposure times indicate a clear successional pattern in dung colonization. Fresh dung supported the highest abundance of Scarabaeidae, particularly *A. aequalis* and *A. lividus*, suggesting rapid colonization shortly after deposition. As decomposition progressed, species composition shifted, with taxa such as *D. bos* and *D. gazella* becoming more frequent in intermediate stages. The strong host-time association reflected by the original chi-square analysis confirms that Scarabaeidae species were not randomly distributed across decomposition stages.

These temporal preferences likely reflect differences in feeding strategy, reproductive behavior, and microhabitat suitability within dung pads. The faunistic indices reinforce the ecological importance of *A. aequalis*, which was classified as constant, dominant, and very abundant. Such characteristics suggest that this species may contribute substantially to dung removal, nutrient cycling, soil aeration, and suppression of pest flies associated with cattle dung (Marchiori *et al.,* 2003).

22. Hymenoptera Parasitoids Collected in Southern Goiás and Minas Gerais, Brazil

A total of 15.827 parasitoid Hymenoptera specimens were recorded in southern Goiás and western Minas Gerais, Brazil. Of these, 6.287 specimens were collected in southern Goiás and 9.540 in western Minas Gerais. The total abundance differed significantly between regions ($\chi^2 = 668.60$; df = 1; $p < 0.0001$), indicating higher parasitoid abundance in western Minas Gerais. Considering sampling methods, yellow buckets collected 5,392 individuals, whereas Malaise traps collected 10.435 individuals. The difference between trap types was significant ($\chi^2 = 1606.86$; df = 1; $p < 0.0001$), showing that Malaise traps captured a larger number of parasitoids than yellow buckets. However, this result should be interpreted with caution because the original study reported differences in the number and structure of traps used (Table 23).

The most abundant families were Ichneumonidae, with 4,562 individuals (28.8%), Braconidae, with 2,532 (16.0%), Diapriidae, with 1,537 (9.7%), Chalcididae, with 1,467 (9.3%), Bethylidae, with 1,335 (8.4%), Encyrtidae, with 1,173 (7.4%), and Eulophidae, with 847 (5.4%). The abundance of families differed significantly ($\chi^2 = 32458.94$; df = 20; $p < 0.0001$), indicating that the parasitoid assemblage was not evenly distributed among families.

Table 23: Families of parasitoids were collected in southern Goiás and western Minas Gerais, Brazil, using yellow buckets and Malaise traps

Superfamily/family	Southern Goiás yellow buckets	Southern Goiás Malaise	Western Minas Gerais yellow buckets	Western Minas Gerais Malaise
Bethylidoidea:				
Bethylidae	139	515	232	449
Dryinidae	6	16	12	35
Megaspilidae	19	10	2	1
Ceraphronoidea:				
Ceraphronidae	99	3	61	10
Chalcidoidea:				
Agaonidae	2	6	4	2
Chalcididae	37	432	94	904
Encyrtidae	370	124	391	288
Eucharitidae	15	19	2	15
Eulophidae	119	170	203	355
Eupelmidae	71	105	49	60
Eurytomidae	9	18	7	5
Mymaridae	18	7	2	1
Pteromalidae	38	12	76	10
Torymidae	53	12	142	16
Cynipoidea:				
Figitidae	51	137	160	281
Evanioidea:				
Evaniidae	20	119	29	180
Ichneumonoidea:				
Braconidae	229	806	283	1.214
Ichneumonidae	441	1.546	351	2.224
Platygastroidea:				
Platygastridae	35	11	44	8
Scelionidae	49	14	169	17
Proctotrupoidea:				
Diapriidae	350	35	909	243
Total	**2.170**	**4.117**	**3.222**	**6.318**

The distribution of parasitoid families among the four sampling categories also differed significantly ($\chi^2 = 5381.12$; df = 60; $p < 0.0001$). In southern Goiás, Ichneumonidae and Braconidae were especially abundant in Malaise traps, while Diapriidae and Encyrtidae were well represented in yellow buckets. In western Minas Gerais, Braconidae and Ichneumonidae were again highly abundant in Malaise traps, whereas Diapriidae, Encyrtidae, and Scelionidae were strongly represented in yellow buckets (Figure 27).

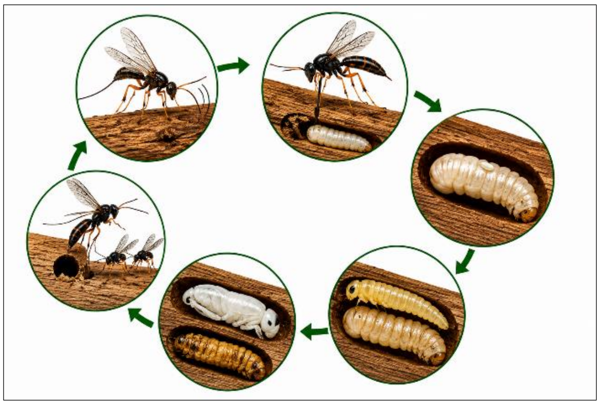

Figure 27: Original schematic representation of the life cycle of a wood-boring parasitoid wasp and its host, showing host location, oviposition, egg deposition, larval development, pupation, and adult emergence. The figure represents parasitoid taxa of the superfamily Ichneumonoidea, especially the families Braconidae (n=1.214) and Ichneumonidae (n=2.224)

The results demonstrate that parasitoid Hymenoptera were abundant and diverse in both southern Goiás and western Minas Gerais. The higher abundance recorded in western Minas Gerais suggests that regional environmental conditions, habitat structure, host availability, and local vegetation may have favored parasitoid occurrence. However, both regions contributed substantially to the total parasitoid fauna. The higher number of specimens collected with Malaise traps indicates that this method was more efficient in capturing active flying parasitoids. This pattern is expected because Malaise traps intercept insects moving through the vegetation, whereas yellow buckets depend more strongly on visual attraction and local activity near the ground. Therefore, the two trap types likely sampled partially different components of the parasitoid community.

The predominance of Braconidae and Ichneumonidae reinforces the ecological importance of Ichneumonoidea in parasitoid communities. These families include many species that attack immature stages of other insects and are frequently associated with natural biological regulation. The high abundance of Bethylidae, Chalcididae, Diapriidae, Encyrtidae, and Eulophidae also shows that several parasitoid lineages were represented in the sampled environments. The significant chi-square results indicate that parasitoid abundance was not randomly distributed by region, trap type, family, or sampling category. These patterns suggest that parasitoid community structure is shaped by both biological factors, such as host availability and host specificity, and methodological factors, such as trap design and sampling efficiency (Marchiori, 2014b).

23. Synanthropic Flies of Medical Importance and Their Parasitoids Collected in Itumbiara, Goiás, Brazil

A total of 5.802 muscoid Diptera and 398 parasitoids were collected using traps baited with bovine liver in Itumbiara, Goiás, Brazil, from May 1998 to April 1999. Among Diptera, the most abundant species were *F. pusio (*1.698 individuals; 29.3%), *Atherigona orientalis* Schiner, 1868 (Diptera: Muscidae) (1.561; 26.9%), *C. megacephala* (785; 13.5%), *C. albiceps* (501), *M. domestica* (451), and *P. chrysostoma* (223). The abundance of Diptera species differed significantly ($\chi^2 = 16574.30$; df = 19; $p < 0.0001$), indicating a highly uneven distribution among species (Table 24).

Table 24: Abundance, relative frequency, and faunistic indices of Diptera and Hymenoptera collected in traps containing bovine liver in Itumbiara, Goiás, Brazil

Taxonomic group	Species	Abundance	Frequency (%)	Faunistic index (%)	A	D
Calliphoridae	*Chrysomya albiceps*	501	8.32	75.0	Z	ND
	Chrysomya megacephala	785	13.50	91.6	X	ND
	Chrysomya putoria	93	1.60	75.0	X	ND
	Cochliomyia macellaria	24	0.40	8.3	Z	ND
Fanniidae	*Fannia pusio*	1.698	29.30	100.0	X	D
Muscidae	*Atherigona orientalis*	1.561	26.90	83.3	X	D
	Cyrtoneurina pararescita	2	0.03	8.3	Z	ND
	Musca domestica	451	7.76	33.0	Y	ND
	Ophyra aenescens	21	1.87	41.6	Y	ND
	Synthesiomyia nudiseta	109	0.36	83.3	X	D
Sarcophagidae	*Euboettcheria Anguilla*	1	0.02	8.3	Z	ND
	Euboettcheria collusor	44	0.75	33.0	Y	ND
	Helicobia sp.	6	0.10	25.0	Y	ND
	Liopygia ruficornis	1	0.02	8.3	Z	ND
	Oxysarcodexia thornax	154	2.65	83.0	X	ND
	Peckia chrysostoma	223	3.85	66.6	X	ND
	Ravinia belforti	9	0.16	25.0	Y	ND
	Sarcodexia lambens	110	1.89	91.6	X	ND
	Sarcophagula occidua	6	0.10	25.0	Y	ND
	Squamatoides trivittatus	9	0.15	25.0	Y	ND
Total Diptera		**5.802**	**100.0**			
Hymenoptera						
Encyrtidae	*Hemencyrtus* sp.	55	13.8	8.3	Z	ND
Pteromalidae	*Nasonia vitripennis*	223	56.0	41.6	Y	ND
	Pachycrepoideus vindemmiae	1	0.3	8.3	Z	ND
	Spalangia endius	13	3.3	8.3	Z	ND
Chalcididae	*Brachymeria podagrica*	106	26.6	75.0	X	ND
Total Hymenoptera	**398**	**100.0**				

Note: A = constancy: X = constant, Y = accessory, Z = accidental; D = dominance: ND = non-dominant, D = dominant. The original table reports 5,802 Diptera; the sum of the listed Diptera rows is slightly different, indicating a minor typographical inconsistency in the source table.

The parasitoid assemblage included *N. vitripennis* (223 individuals; 56.0%), *B. podagrica* (106; 26.6%), Hemencyrtus sp. (55; 13.8%), *S. endius* (13; 3.3%), and *P. vindemmiae* (1; 0.3%). Parasitoid abundance differed significantly among species (χ^2 = 408.03; df = 4; p < 0.0001), showing the predominance of *B. podagrica* and *N. vitripennis* (Table 25).

Table 25: Parasitism obtained from dipteran pupae collected in traps containing bovine liver in Itumbiara, Goiás, Brazil

Parasitoid species	Frequency	Host species	Host frequency	Parasitism rate (%)
Hemencyrtus sp.	16	*Euboettcheria collusor*	44	36.3
	39	*Synthesiomyia nudiseta*	109	35.7
Brachymeria podagrica	106	*Peckia chrysostoma*	223	47.5
Nasonia vitripennis	184	*Chrysomya albiceps*	501	36.7
	32	*Oxysarcodexia thornax*	154	29.7
	7	*Synthesiomyia nudiseta*	109	6.4
Pachycrepoideus vindemmiae	1	*Fannia pusio*	1.698	0.1
Spalangia endius	10	*Fannia pusio*	1.698	0.6
	3	*Oxysarcodexia thornax*	154	33.3
Total parasitoids	398			

The overall parasitism rate was 6.85%. Parasitism varied among host species and parasitoids. *Nasonia vitripennis* emerged mainly from pupae of *C. albiceps, O. thornax*, and *S. nudiseta*; *B. podagrica* was associated with *P. chrysostoma; Hemencyrtus* sp. was associated with *S. nudiseta* and *Euboettcheria collusor* (Curran & Walley, 1934) (Diptera: Sarcophagidae); and *S. endius* was associated with *F. pusio* and *O. thornax*. The comparison between parasitized and non-parasitized pupae among host species was significant (χ^2 = 747.96; df = 5; p < 0.0001). The original article also reported significant parasitoid preference among hosts (χ^2 = 104.09; df = 20; p < 0.05).

Seasonal variation was evident among the main fly species listed in Table 26. The highest monthly totals occurred in December and January, coinciding with the warm and humid season. The monthly distribution of the selected Diptera differed significantly (χ^2 = 4209.03; df = 11; p < 0.0001). For the parasitoids listed in Table 26, the monthly distribution was also significant (χ^2 = 309.13; df = 11; p < 0.0001), with B. podagrica more abundant in October and April, Hemencyrtus sp. peaking in June and August, and N. vitripennis more abundant in May and July (Table 26).

Table 26: Monthly frequency of Diptera and parasitoids collected in bovine liver from May 1998 to April 1999

Hosts species	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total
Atherigona orientalis	50	92	46	30	25	30	563	300	400	25	0	0	1.561
Chrysomya albiceps	30	30	19	16	19	39	24	156	168	0	0	0	501
Chrysomya megacephala	63	12	11	42	14	16	16	485	113	0	11	2	785
Chrysomya putoria	22	2	0	3	2	2	3	24	33	0	2	0	93
Fannia pusio	553	45	70	66	42	189	214	95	185	74	36	129	1.698
Oxysarcodexia thornax	3	11	13	13	3	4	63	14	30	0	0	0	154
Peckia chrysostoma	8	12	0	11	0	0	13	112	9	9	0	49	223
Sarcodexia lambens	7	7	6	2	6	5	20	22	30	0	2	3	110
Synthesiomyia nudiseta	10	12	18	19	12	13	5	10	9	1	0	0	109
Host subtotal	**746**	**223**	**183**	**202**	**123**	**298**	**921**	**1218**	**977**	**109**	**51**	**183**	**5.234**
Parasitoids													
Brachymeria podagrica	4	0	9	6	4	13	6	10	8	0	0	46	106
Hemencyrtus sp.	0	26	3	26	0	0	0	0	0	0	0	0	55
Nasonia vitripennis	96	13	46	19	19	30	0	0	0	0	0	0	223
Parasitoid subtotal	100	39	58	51	23	43	6	10	8	0	0	46	384
Monthly total	**846**	**262**	**241**	**253**	**146**	**341**	**927**	**1228**	**985**	**109**	**51**	**229**	**5618**

The results show that bovine liver bait attracted a diverse assemblage of synanthropic Diptera and their parasitoids in Itumbiara. The dominance of *Atherigona orientalis* Schiner, 1868 (Diptera: Muscidae) and *F. pusio* indicates that these species were highly adapted to the sampled environment and bait type. Their high abundance, together with the occurrence of Calliphoridae, Fanniidae, Muscidae, and Sarcophagidae, reinforces the importance of decomposing animal substrates for the development of flies of medical and veterinary relevance.

The parasitoid fauna was dominated by *B. podagrica* and *N. vitripennis*. The significant chi-square result for parasitoid abundance indicates that the community was not evenly distributed among species. This pattern suggests differences in host use, searching behavior, host suitability, and adaptation to the local substrate. The presence of *Hemencyrtus* sp., *P. vindemmiae*, and *S. endius* also indicates that several parasitoid taxa can exploit pupae developing in synanthropic fly communities. The significant variation in parasitism among hosts shows that parasitoid activity was strongly influenced by host identity (Figure 28).

Figure 28: Biological interaction between synanthropic flies and their parasitoids in bovine liver bait. This figure illustrates the attraction of medically important flies to decomposing bovine liver, followed by egg deposition, larval development, pupation, and parasitoid activity. The parasitoids are represented with four wings, attacking or emerging from fly pupae, highlighting their role in the natural regulation of synanthropic Diptera populations

Higher parasitism was observed in associations such as *B. podagrica* with *P. chrysostoma* and *N. vitripennis* with *C. albiceps*. These patterns suggest that some hosts may be more suitable or more accessible to parasitoids, depending on pupal size, microhabitat, developmental stage, and exposure within the substrate. Seasonality also influenced fly and parasitoid occurrence. The highest abundance of flies during the warm and humid months may be related to favorable environmental conditions for larval development and substrate decomposition. Parasitoids showed different monthly peaks, indicating that their occurrence may depend on host availability, climatic conditions, and species-specific biological cycles (Marchiori, 2001b).

24. Parasitoids of Immature Stages of Synanthropic Diptera Collected in Several Environments in Itumbiara, Goiás

A total of 971 parasitoids were collected from immature stages of Diptera in six environments in Itumbiara, Goiás, Brazil, from January 1998 to December 1999. The environments included cattle dung in pastures, cattle dung in corrals, frugivorous flies, traps baited with bovine liver, pig carcasses, and food remains. The highest numbers of parasitoids were recorded in cattle dung in pastures (408 individuals), and traps baited with bovine liver (398 individuals), followed by cattle dung in corrals (89), frugivorous flies (48), pig carcass (18), and food remains (10).

The distribution of parasitoids among environments differed significantly ($\chi^2 = 1102.23$; df = 5; $p < 0.0001$), indicating that parasitoid abundance was not evenly distributed among the sampled substrates and environments. The highest parasitism values reported in the original table were observed in cattle dung in pastures (7.08%), traps baited with bovine liver (6.61%), and frugivorous flies (6.36%). Lower parasitism values were recorded in cattle dung in corrals (4.53%), food remains (2.4%), and pig carcasses (0.40%).

The parasitoid assemblage was composed mainly of Braconidae, Chalcididae, Diapriidae, Encyrtidae, Eucoilidae, Figitidae, Pteromalidae, and Staphylinidae. Among the species listed in the table, *N. vitripennis* was the most abundant, with 223 individuals, followed by *S. drosophilae* with 154, *B. podagrica* with 106, *T. atrocoxalis* with 80, *P. egeria* with 63, *H. herbertii* with 55, and *S. nigroaenea* with 49. The abundance of parasitoid species differed significantly ($\chi^2 = 1072.05$; df = 17; $p < 0.0001$), showing strong dominance of a few taxa (Table 27).

Table 27: Abundance of parasitoids collected in Itumbiara, Goiás, Brazil, from January 1998 to December 1999

Taxonomic group	Parasitoids species	Cattle dung pastures	Cattle dung corrals	Frugivorous flies	Bovine liver traps	Pig carcass	Food remains
Coleoptera							
Staphylinidae:	*Aleochara notula*	3	0	0	0	0	0
Hymenoptera							
Braconidae	*Doryctobracon areolatus*	0	0	43	0	0	0
Chalcididae	*Brachymeria podagrica*	0	0	0	106	0	0
Diapriidae	*Trichopria* sp.	39	0	0	0	0	0
Encyrtidae	*Hemencyrtus herbertii*	0	0	0	55	0	0
Eucoilidae	*Aganaspis pelleranoi*	0	0	3	0	0	0
	Paraganaspis egeria	32	26	0	0	5	0
	Triplasta atrocoxalis	72	8	0	0	0	0
Figitidae	*Neralsia splendens*	1	14	0	0	0	0
Pteromalidae	*Muscidifurax raptor*	0	6	0	0	0	1
	Muscidifurax zaraptor	2	0	0	0	0	0
	Nasonia vitripennis	0	0	0	223	0	0
	Pachycrepoideus vindemmiae	0	25	2	1	6	9
	Spalangia cameroni	34	7	0	0	0	0
	Spalangia drosophilae	154	0	0	0	0	0
	Spalangia endius	17	0	0	13	7	0
	Spalangia nigra	1	0	0	0	0	0
	Spalangia nigroaenea	46	3	0	0	0	0
Total		**408**	**89**	**48**	**398**	**18**	**10**
Parasitism rate (%)		**7.08**	**4.53**	**6.36**	**6.61**	**0.4**	**2.4**

Note: The species values visible in the table sum to 964 individuals, while the original total reports 971 individuals. Note: The article reports 971 parasitoids in total. However, direct summation of the species values visible in Table 27 gives 964 individuals, indicating a difference of seven individuals in relation to the total reported by the original article. The environmental totals reported in the original table were maintained (Figure 29).

Figure 29: Schematic representation of parasitoids associated with immature stages of synanthropic Diptera collected in several environments in Itumbiara, Goiás, Brazil. The figure illustrates the main substrates and sampling contexts evaluated, including cattle dung in pastures and corrals, frugivorous flies, bovine liver traps, pig carcasses, and food remains. These environments supported distinct parasitoid assemblages, with higher abundance recorded in cattle dung from pastures and in traps baited with bovine liver

The association between parasitoid species and environments was also significant ($\chi^2 = 2593.56$; df = 85; $p < 0.0001$). This result indicates that parasitoids were not randomly distributed among substrates. *Pachycrepoideus vindemmiae* occurred in several environments, including cattle dung in corrals, frugivorous flies, traps baited with bovine liver, pig carcass, and food remains. *Spalangia cameroni* and *S. endius* occurred in several host associations, while *B. podagrica* and *N. vitripennis* were strongly associated with traps baited with bovine liver. *Paraganaspis egeria* and *T. atrocoxalis* were frequent in cattle dung environments, especially in pastures (Table 28).

Table 28: Host associations of parasitoids collected in Itumbiara, Goiás, Brazil, from January 1998 to December 1999

Parasitoid species	Host species	Parasitoid species	Host species
Aleochara notula	*Sarcophagula occidua*	*Spalangia cameroni*	*Brontaea quadristigma; Brontaea debilis; Cyrtoneurina pararescita; Musca domestica; Palaeosepsis; Sarcophagula occidua*
Aganaspis pelleranoi	*Anastrepha fraterculus*	*Spalangia drosophilae*	*Palaeosepsis; Sarcophagula occidua; Sphaeroceridae*
Brachymeria podagrica	*Peckia chrysostoma*	*Spalangia endius*	*Chrysomya albiceps; Brontaea quadristigma; Cyrtoneurina pararescita; Oxysarcodexia thornax; Palaeosepsis; Sarcophagula occidua*
Doryctobracon areolatus	*Ceratitis capitata; Anastrepha fraterculus*	*Spalangia nigra*	*Sarcophagula occidua*
Hemencyrtus herbertii	*Euboettcheria collusor; Synthesiomyia nudiseta*	*Spalangia nigroaenea*	*Brontaea quadristigma; Brontaea debilis; Cyrtoneurina pararescita; Palaeosepsis; Sarcophagula occidua*
Muscidifurax raptor	*Musca domestica; Palaeosepsis; Sarcophagula occidua*	*Trichopria* sp.	*Brontaea quadristigma; Palaeosepsis; Sarcophagula occidua; Sphaeroceridae*
Muscidifurax zaraptor	*Brontaea quadristigma; Palaeosepsis*	*Triplasta atrocoxalis*	*Palaeosepsis; Sarcophagula occidua; Sphaeroceridae*
Neralsia splendens	*Sarcophagula occidua*	---------------	---------------
Nasonia vitripennis	*Chrysomya albiceps; Oxysarcodexia thornax; Synthesiomyia nudiseta*	---------------	---------------
Pachycrepoideus vindemmiae	*Anastrepha fraterculus; Fannia pusio; Musca domestica; Ophiura* sp.; *Sarcophagula occidua*	---------------	---------------
Paraganaspis egeria	*Brontaea quadristigma; Chrysomya albiceps; Sarcophagula occidua*	---------------	---------------

The results demonstrate that different substrates and environments in Itumbiara supported distinct parasitoid assemblages associated with synanthropic Diptera. Cattle dung in pastures and traps baited with bovine liver accounted for the highest parasitoid abundances, indicating that these substrates provided favorable conditions for host development and parasitoid activity. The significant chi-square result for environments confirms that parasitoid occurrence was strongly influenced by substrate type and ecological context.

The predominance of species such as *B. podagrica, H. herbertii, N. vitripennis, P. egeria, S. drosophilae,* and *T. atrocoxalis* indicates that parasitoid communities associated with synanthropic Diptera are structured by host availability and substrate characteristics. The broad occurrence of *P. vindemmiae* in different environments reinforces its generalist behavior and ecological plasticity, whereas other species showed more restricted associations. The significant association between parasitoids and environments suggests that host-parasitoid relationships were not random. Some parasitoids occurred mainly in cattle dung, while others were associated with frugivorous flies, bovine liver traps, carcasses, or food remains. These differences may reflect host specificity, searching behavior, host density, substrate quality, and microclimatic conditions. The presence of parasitoids across several substrates highlights their ecological importance as natural enemies of Diptera in urban, rural, and peri-urban environments (Marchiori, 2000d).

5.0. DISCUSSION

The synthesis of the reviewed studies showed that parasitoids are strongly associated with substrates that support Diptera development, particularly animal feces, carcasses, bovine liver, bovine kidney, fruits, and decomposing organic matter. These substrates provide suitable conditions for larval development and pupation of several fly species, creating favorable opportunities for parasitoid attack. The frequent occurrence of parasitoids in cattle dung, buffalo dung, pig carcasses, bovine tissues, and fruit substrates confirms the ecological importance of these environments as reservoirs of host–parasitoid interactions. Braconidae, Chalcididae, Diapriidae, Encyrtidae, Figitidae, and Pteromalidae indicate that parasitoid communities associated with Diptera are taxonomically diverse and ecologically complex (Marchiori, 2021; Marchiori and

Malheiros, 2026; Marchiori and Malheiros, 2026a; Marchiori and Malheiros, 2026b).

Species such as *B. podagrica*. *G. quadridentata, H. herbertii, N. vitripennis, P. egeria, P. vindemmiae, S. cameroni, S. drosophilae, S. endius, T. atrocoxalis*, and *T. coxalis* were repeatedly recorded in different studies, showing their importance as natural enemies of synanthropic and frugivorous. Diptera were repeatedly recorded in different studies, showing their importance as natural enemies of synanthropic and frugivorous Diptera (Marchiori, 2021; Marchiori and Malheiros, 2026; Marchiori and Malheiros, 2026a; Marchiori and Malheiros, 2026b).

The chi-square analyses demonstrated that most patterns observed in the reviewed studies were not random. Significant differences were detected in parasitoid abundance, host abundance, parasitism among hosts, distribution among substrates, trap efficiency, habitat occurrence, monthly variation, and host–parasitoid associations. These results indicate that parasitoid communities are influenced by host density, substrate type, environmental conditions, and sampling method. In particular, differences between pasture and forest areas, cattle dung and buffalo dung, Malaise and yellow pan traps, and different decomposition stages show that habitat and resource availability are key factors structuring insect communities. The studies involving Scarabaeidae and Coleoptera also expanded the ecological interpretation of the review (Marchiori, 2021; Marchiori and Malheiros, 2026; Marchiori and Malheiros, 2026a; Marchiori and Malheiros, 2026b).

Dung beetle succession and Coleoptera extraction using Berlese funnels showed that decomposing substrates are not only important for Diptera and parasitoids, but also support a broader arthropod community. These organisms participate in nutrient cycling, organic matter decomposition, soil aeration, and ecological succession. Therefore, the association among Coleoptera, Diptera, and Hymenoptera parasitoids of decomposing substrates should be interpreted as part of a wider ecological network. Despite methodological differences among the reviewed studies, the integrated analysis revealed consistent patterns. Organic substrates were the main centers of insect activity; parasitoid abundance generally followed host availability, and some parasitoid taxa showed clear associations with particular hosts or substrates (Marchiori, 2021; Marchiori and Malheiros, 2026; Marchiori and Malheiros, 2026a; Marchiori and Malheiros, 2026b).

These findings reinforce the relevance of parasitoids as natural regulators of Diptera populations and highlight their potential importance in biological control, especially against flies of medical and veterinary importance. However, differences in sampling design, exposure time, locality, and identification level should be considered when comparing studies. Overall, the reviewed data demonstrate that parasitoid–host interactions in Brazil are diverse, structured, and strongly influenced by ecological conditions. The integration of experimental results and chi-square analyses provides a broader view of parasitoid ecology and supports the importance of continued studies on natural enemies associated with Coleoptera, Diptera, and decomposing organic substrates (Figure 29) (Marchiori, 2021; Marchiori and Malheiros, 2026; Marchiori and Malheiros, 2026a; Marchiori and Malheiros, 2026b).

Figure 29: Integrative schematic overview of the main substrates, hosts, associated insects, parasitoids, and sampling methods analyzed in the article. The figure summarizes parasitoid–host interactions involving Diptera and other insects in cattle dung, buffalo dung, fruit substrates, bovine liver traps, pig carcasses, food remains, puparia, Coleoptera assemblages, Scarabaeidae succession, yellow pan traps, Malaise traps, pitfall traps, and Berlese funnel extraction. Together, these systems illustrate the ecological diversity of parasitoids and associated arthropods in decomposing organic substrates in Brazil

6.0. CONCLUSION

The integrated analysis showed that parasitoids associated with Diptera and other insects in Brazil form diverse and structured communities, strongly influenced by host availability, substrate type, habitat, seasonality, and sampling method. Organic substrates such as animal feces, carcasses, fruits, bovine liver, and bovine kidney were important environments for the development of hosts and the activity of parasitoids. The chi-square analyses confirmed that most patterns of abundance, parasitism, host association, substrate use, trap efficiency, and temporal distribution were not random. Therefore, these parasitoids represent important natural enemies of synanthropic, frugivorous, and medically or veterinary important flies, with ecological relevance and potential application in biological control.

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