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Mini review of parasitoids of insect pest in Brazil

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Abstract

In the process of manipulating agroecosystems, man adopts strategies that often conflict with those of the nature by imposing its interests and objectives to increase the food and fiber production. As a result, populations of certain species of herbivores, such as insects and mites phytophagous, become numerically so high that they damage the crops to the point of reducing their productivity and, consequently, their economic income. The aim of the mini review is to provide a bibliographic summary of parasitoids of the Order Hymenoptera collected from insect pests in Brazil. The research was carried out in studies related to the theme with emphasis on the quantitative aspects of the genera, and species (Taxonomic groups). A bibliographic search was carried out that contained papers published from 1998 to June 2021. The mini review was prepared in Goiânia, Goiás from March to June 2021 using the Electronic Scientific Library Online (Scielo) and internet. Thus, biological control aims to reduce the population level of a species classified as a pest, keeping it below the level in which it is capable of causing economic harm.

Keywords: Insect; Hymenotera; Natural enemy; Bibliographic summary

1. Introduction

In the process of manipulating agroecosystems, man adopts strategies that often conflict with those of the nature by imposing its interests and objectives to increase the food and fiber production. As a result, populations of certain species of herbivores, such as insects and mites phytophagous, become numerically so high that they damage the crops to the point of reducing their productivity and, consequently, their economic income. In this situation, these insects reach the status of "plague [1].

The parasitoid larvae develop on or inside the host's body; depending on their location, they are called ecto or endoparasitoids. *Bracon mellitor* Say 1836 (Hymenoptera: Braconidae) and *Catolaccus grandis* (Burks, 1954) (Hymenoptera: Pteromalidae) are ectoparasitoids of the cotton boll weevil larva *Anthonomus grandis* Boheman, 1843 (Coleoptera: Curculionidae), while the various species of *Trichogramma* (Hymenoptera: Trichogrammatidae) are endoparasitoids of pest lepidopteran eggs such as the sugarcane borer *Diatraea saccharalis* (Fabricius, 1794) (Lepidoptera, Crambidae), the tomato moth *Tuta absoluta* (Meyrick 1917) (Lepidoptera, Gelechiidae), the *Alabama argillacea* Liübner, 1818 (Lepidoptera: Noctuidae) weevil and the da caterpillar - ear *Helicoverpa zea* (Boddie, 1850) (Lepidoptera, Noctuidae) [2].

Almost a century has passed since the establishment of the first biological control program using parasitoids in Brazil, which occurred in 1916, when *Encarsia berlesei* (Howard, 1906) (= *Prospaltella berlesei*) (Hymenoptera, Aphelinidae) was introduced in the State of São Paulo. Paulo for the control of the white mulberry mealybug *Pseudaulacaspis pentagona* (Targ Tozz, 1885) (Hemiptera: Diaspididae). Since then, many other programs have been established,

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especially in the last 30 years, when the interest in pest control methods that are less harmful to the environment grew considerably in the world (Figures1, 2 and 3) [2].

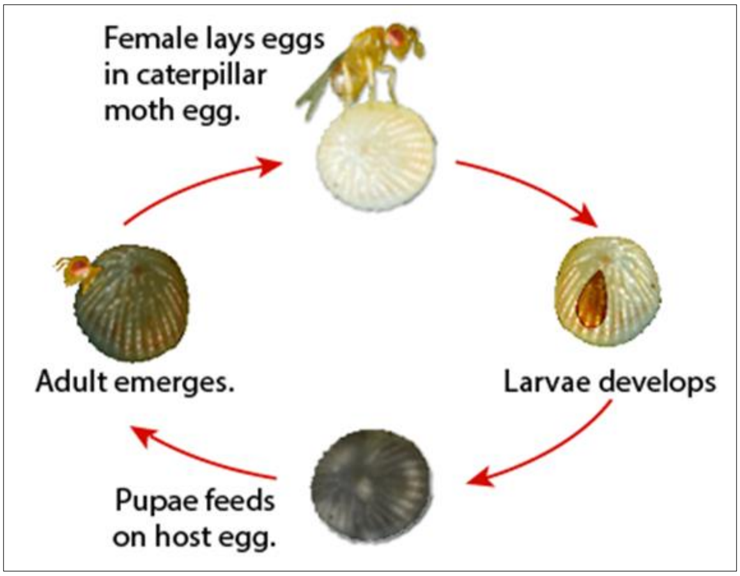

Figure 1 Life cycle of Trichogramma sp. (Hymenoptera: Trichogrammatidae) egg parasitoid**;** Source: https://www.researchgate.net/figure/Life-cycle-of-Trichogramma-spps_fig15_335978434

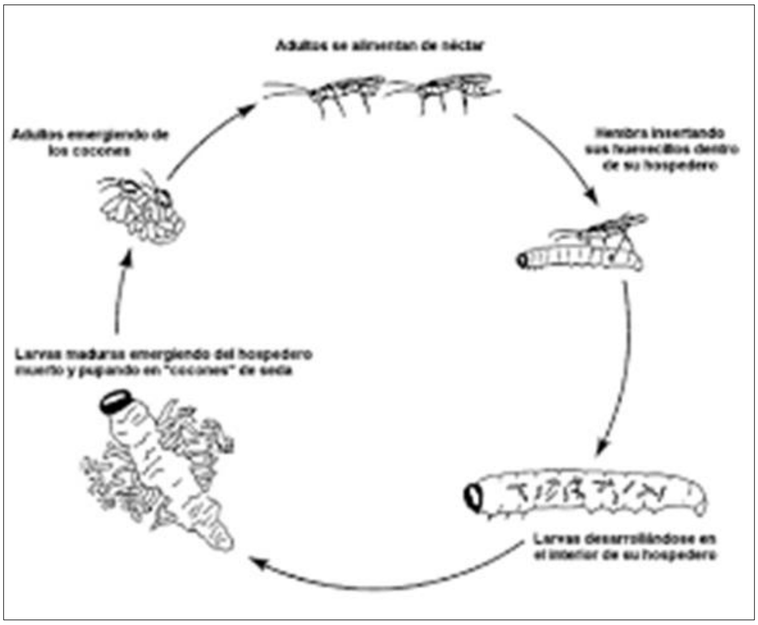

Figure 2 Larval parasitoid life cycle; Source: Taken from: Nicholls, C.I.; Altieri, M.A.; Sánchez, J. 1999. Practical manual of biological control for sustainable agriculture

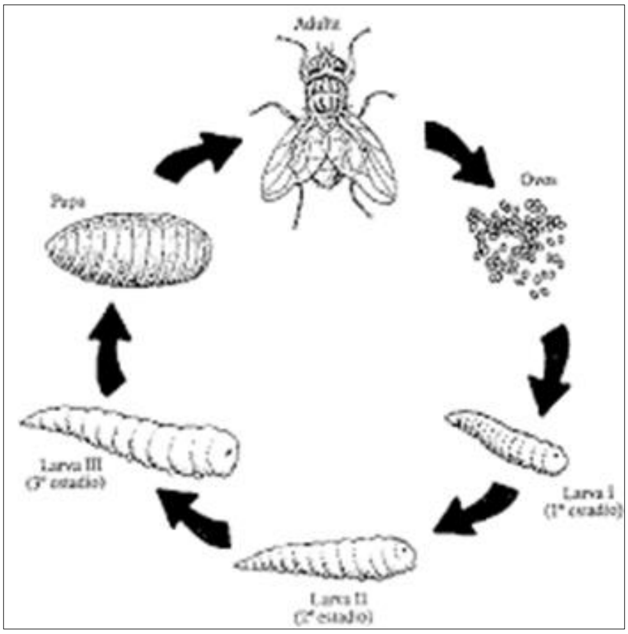

Figure 3 Pupal parasitoid life cycle; Source: https://repositorio.ufsc.br/xmlui/bitstream/handle/123456789/182253/TCC_Final.pdf?sequence=1&isAllowed=y

The aim of the mini review is to provide a bibliographic summary of parasitoids of the Order Hymenoptera collected from insect pests in Brazil.

2. Methods

For the elaboration of this mini review that consists in the construction of a bibliographical summary of the main groups of parasitoids of the Order Hymenoptera, with emphasis on the parasitoid hymenoptera collected in pest insects. A bibliographical research was carried out which contained articles published from 1999 to June 2021 on the quantitative aspects of Families, Subfamilies, Genera and Species. The mini review was carried out from February to July 2021 through the Electronic Scientific Library Online (Scielo) and Internet (Google) in Goiânia, Goiás, Midwest region, Brazil.

3. Studies performed

3.1. Study 1

This work presents the results of distribution and parasitism of braconids obtained in more than five years of fruit fly host fruit collection in 71 municipalities in the state of São Paulo.

In 33 of them (46%), fruits with fruit fly larvae parasitized by braconids were obtained. Forty-two, 134 fruits belonging to 26 species of fruit fly host plants were collected. Of the 38,750 pupae obtained, 21,452 tephrithids emerged – 85.4% of *Anastrepha* species and 14.6% of *Ceratitis capitata* (Wiedemann, 1824) (Diptera: Tephritidae).

A total of 3,008 parasitoids were collected (2,894 opiates and 114 alisilines), the majority belonging to *Doryctobracon areolatus* (Szépligeti, 1911) (Hymenoptera: Braconidae) (77.5%). The collection percentages of the other opiates were: *Utetes anastrephae* (Viereck, 1913) (8.8%), *Doryctobracon brasiliensis* (Szépligeti, 1911) (Hymenoptera: Braconidae) (7.6%) and *Opius bellus* Gahan, 1930 (Hymenoptera: Braconidae) (2.3%). *Asobara anastrephae* (Muesebeck, 1958) (Hymenoptera: Braconidae: Alysiinae) corresponded to 3.8% of the collected parasitoids (Figure 4).

Figure 4 Fruit fly parasitoids in Brazil; Source: https://www.slideshare.net/PNMF/controle-biolgico-de-moscasdasfrutas*.*

Doryctobracon areolatus, collected in most sampled locations (30 municipalities), was associated with the highest number of fruit fly hosts (26 species). Considering together the flies and parasitoids collected (24,460 specimens), the survival of the fly pupae was 63.1% [3].

3.2. Study 2

To obtain more information about the species composition of egg parasitoids of stink bugs, we carried out surveys on their seasonal occurrence in soybean fields in the Triângulo Mineiro region (Brazil).

A total of 118 egg masses was collected in Conquista in the 1993/94 season. Of these, 26.3% were of *Euschistus heros* (Fabricius, 1798) (Heteroptera: Pentatomidae) and 73.7% of *Piezodorus guildinii* (Westwood, 1837) (Hemiptera: Aphidoidae). In 1994/95, the total number of egg masses collected was 39: 10.2% of *E. heros* and 89.7% of *P. guildinii*. The population level of both species was higher during the first year of the study than during the second. Numbers of *P. guildinii* were higher than those of *E. heros* in 1993/94, but population reached similar numbers in 1994/95.

Telenomus podisi Ashmead, 1893 (Hymenoptera: Scelionidae) (Figure 4) was the only species that successfully attacked *E. heros* eggs: it parasitized 62.9% of all eggs in 1993/94, but no parasitized eggs were found in 1994/95. A total of 810 (50.2%) and 182 (31.3%) eggs of *P. guildinii* were parasitized in 1993/94 and 1994/95 respectively. The predominant parasitoid species was *T. podisi*, but we also found *Trissolcus brochymenae* (Ashmead, 1887) (Hymenoptera: Scelionidae) and *Ooencyrtus* sp. (Hymenoptera: Chalcididae) attacking the stink bug eggs [4].

Figure 5 *Telenomus podisi* Ashmead 1893 (Hymenoptera: Scelionidae) parasitizing pest insect eggs of *Euschistus heros* (F.) (Heteroptera: Pentatomidae); Source: https://en.wikipedia.org/wiki/Telenomus_podisi*.*

3.3. Study 3

The present study aimed to identify parasitoids that naturally occur on eggs *Leptoglossus zonatus* (Dallas, 1852) (Hemiptera: Coreidae) and to report the occurrence of the parasitoid *Anastatus* sp. (Hymenoptera: Eupelmidae) in this host.

The experiment was performed at the Agronomy School Farm (Site 1) and at the Santa Maria Farm (Site 2) from December 2001 to February 2002. Both farms are located in Itumbiara County, State of Goiás, Central Brazil (18°25'S; 49°13'W).

A total of 113 eggs of *L. zonatus* were collected from January to February 2002, from which 40 nymphs (35.4%) of the host species and 64 parasitoids (56.6%), from five different species, emerged. Nine of the eggs (8.0%) did not produce either nymphs or parasitoids. The percentage of parasitism recorded was 56.6%. At Sites 1 and 2, 41 and 72 eggs of *L. zonatus* were, respectively.

Number of specimens (Site 1): *Brasema* sp. (02) (Hymenoptera: Eupelmidae), *Gryon gallardoi* (Brèthes, 1914) (Hymenoptera: Scelionidae) (11). Number of specimens (Site 2): *Anastatus* sp. (Hymenoptera: Eupelmidae) (05), *G. gallardoi* (40) and *Trissolcus* sp. (Hymenoptera: Scelionidae) (06). Among the parasitoids collected, *G. gallardoi* was the most frequent species representing 79.6% of the specimens. The parasitic rate of the parasitoids *Anastatus* sp., *Brasema* sp. (Hymenptera: Eupelmidae), *G. gallardoi* and *Trissolcus* sp. was 4.4%, 1.8%, 45.1% and 5.3%, respectively [5].

3.4. Study 4

The objective of this study was to report the parastoids of Diptera collected in traps of different colors in the south of Goias state.

This study was conducted within the School of Agronomy of the municipality of Itumbiara (18º25´S – 49º13´W), in the southern Goiás State.

Between March and December 2006, 17 parasitoid specimens were collected from the yellow trap, 15 from the blue trap, 12 from the white trap, 37 from the black trap, one from the green trap and three from the red trap. The greater absorption of heat by the black trap caused a faster decomposition of the bovine liver, thus attracting a greater number of parasitoids. The parasitoids did not present any preference for any of the trap colors (F=0.772; P=0.58).

The most frequently collected parasitoid species was *Brachymeria podagrica* (Fabricius, 1719) (Hymenoptera: Chalcididae), with 80.0%, which was possibly because of seasonal factors or the search capacity presented by this species. With regard to the attraction of the parasitoid species for trap color, it was found that *Brachymeria* sp. (Hymenoptera: Chalcididae) presented attraction for red; *B. podagrica* (presented attraction for yellow, white, black and green; *Spalangia cameroni* Perkins, 1910 (Hymenotera: Pteromalidae) presented attraction for white; and *Spalangia endius* Walker 1839 (Hymenotera: Pteromalidae) presented attraction for red (F=3.11; P=0.05) [6].

3.5. Study 5

The present study aimed to identify the parasitoids collected in insect pests in agricultural area in southern Goiás and in southern of Minas Gerais, Brazil. A total of 113 eggs of *Leptoglossus zonatus* (Dallas, 1852) (Hemiptera: Coreidae) were collected from January to February 2002, from which 40 nymphs (35.4%) of the host species and 64 parasitoids (56.6%), from five different species, emerged. Nine of the eggs (8.0%) did not produce either nymphs or parasitoids. Among the parasitoids collected, *Gryon gallardoi* (Brethes, 1914) (Hymenoptera: Scelionidae) was the most frequent species representing 79.6% of the specimens. The parasitism also reported in the genera *Gryon, Neolreleya* (Hymenoptera: Eurytomidae), *Ooencrytus* (Hymenoptera: Encyrtidae) and *Anastatus* (Hymenoptera: Eupelmidae) on eggs of *L. zonatus*.

Between March to November of 2001, 285 specimens of *Pachycrepoideus vindemmiae* (Rondani, 1875) (Hymenoptera: Pteromalidae) were obtained from 963 pupae of *Zaprionus indianus* (Gupta, 1970) (Diptera: Drosophilidae). Between March and November 2001, 03 specimens of *Leptopilina boulardi* Barbotin, Carton & Kelner Pillaut, 1979 (Hymenoptera: Figitidae) (Figure 8) collected in the months of September (two specimens) and November (one specimen) of 2001 in the spring, were obtained from 139 pupae of *Z. indianus.*

During the study, from 500 *Tuta absoluta* (Meyrick, 1917) (Lepidoptera: Gelechiidae) pupae obtained, emerged parasitoides of the species *Bracon* sp. (Hymenoptera: Braconidae), *Earinus* sp. (Hymenoptera: Braconidae) and *Conura* sp. (Hymenoptera: Chalcididae). *Bracon* sp. was the most collected species with 60.0%. The natural occurrence of the genera *Bracon*, *Earinus*, and *Conura* inside the greenhouse suggests a close interaction among these species and their tomato leaf miner host.

Larvae belonging to 40 species were collected *Lonomia* sp. Of which seven Hymenoptera were parasitized by ectoparasites being four per *Anastatus* sp. (Eupelmidae) and three *Aprostocetus* sp. (Eulophidae) (Figure 9) was the most frequent specie *Anastatus* sp. to 57.1% [7].

Figure 6 Parasitoids of *Tuta absoluta* (Meyrick, 1917) (Lepidoptera: Gelechiidae), *Conura* sp., *Bracon* sp. and *Earinus* sp.

3.6. Study 6

The purpose of the paper is to report the species of dipterans parasitoids in poultry feces on farms, buffalo, and cattle in the field in Brazil (Figura 6).

Were obtained from bovine feces 628 pupae of dipterans in buffalo feces, 3.437 pupae were collected and from chicken feces 2,799 pupae, from which 78, 172 and 504 parasitoids emerged, respectively.

The most frequent species in bovine, of buffalo and chicken feces were: *Gnathopleura quadridentata* Wharton 1986 with 25.6%, *Spalangia drosophilae* Ashmead 188 with 21.5% and *Pachycrepoideus vindemmiae* (Rondani, 1875) with 46.8%, respectively.

The total percentage of parasitism in bovine, of buffalo and chicken feces were 12.4% (78/628), 45.0% (172/3473) and 18.0%. (504/2799), respectively. The highest percentage of parasitism in bovine feces was presented by the parasitoid *G. quadridentata,* with 28.6% (20/70) in the buffalo feces they were presented by the parasitoids *Spalangia nigra* Latreille 1805 (Hymenoptera: Pteromalidae) with 5.26% (1/19) and *Spalangia nigroaenea* Curtis 1839 (Hymenoptera: Pteromalidae) also with 5.26% (1/19) and in chicken feces it was *P. vindemmiae* with 46.8% (347/2083).

Regarding the attraction of parasitoids to dipterans, it was found that *Muscidifurax raptorellus* Kogan & Legner, 1970 (Hymenoptera: Pteromalidae) was attracted to *Fannia pusio* (Wiedemann, 1830) (Diptera Fanniidae); *Nasonia vitripennis* (Walker, 1836) (Hymenoptera: Pteromalidae) by *Chrysomya megacephala* (Fabricius, 1794) (Diptera: Calliphoridae); *P. vindemmiae* by *F. pusio*, *Musca domestica* L. 1758 (Diptera: Muscidae) and *Ornidia obesa* (Fabricius, 1775) (Diptera: Syrphidae); *Spalangia cameroni* Perkins, 1910 (Hymenoptera, Pteromalidae) by *O. obesa; S. drosophilae* by *Palaeosepsis* sp. (Diptera: Sepsidae); *Spalangia endius* Walker, 1839 (Hymenoptera: Pteromalidae) by *C. megacephala* and *M. domestica*; *S. nigra* by *M. domestica*; *S. nigroaenae* by *M. domestica*; *Spalangia* sp. by *M. domestica*; *Tachinaephagus zealandicus* Ashmead, 1904 (Hymenoptera: Encyrtidae) by *M. domestica* (X^2=711,80; GL=36; P<0,05).

Regarding the preference of parasitoids for their hosts in bovine feces, it was found that *G. quadridentata* showed preference for *Oxysarcodexia thornax* (Walker, 1849) (Diptera: Sarcophagidae); *Kleidotoma nigra* (Hartig, 1840) (Hymenoptera: Figitidae) showed preference for *Brontaea quadristigma* (Thomson, 1869) (Diptera: Muscidae); *P. vimdemmiae* showed preference for *Ravinia belforti* (Prado & Fonseca, 1932) (Diptera: Sarcophagidae); *Paraganspis egeria* Díaz, Gallardo & Walsh 1996 (Hymenoptera: Figitidae) showed preference for *Palaeosepsis* spp. (Diptera; Sepsidae); *S. cameroni* showed preference for *Brontaea debilis* (Williston, 1896) (Diptera: Muscidae), *B. quadristigma*, *M. domestica* and *R. belforti*; *S. drosophilae* showed preference for *Archisepsis scabra* (Loew, 1861) (Diptera: Sepsidae) and *B. quadristigma* and *Palaeosepsis* spp.; *S. endius* showed preference for *B. quadristigma* and *Palaeosepsis* spp.; *S. nigra* showed preference for *Cyrtoneurina pararescita* Couri 1995 (Diptera: Muscidae) and *R. belforti*; *S. nigroaenea* showed preference for *B. debilis, B. quadristigma, C. pararescita* and *R. belforti*; *Trichopria* sp. (Hymenoptera: Diapriidae) showed preference for *Palaeosepsis* spp.; *Triplasta atrocoxalis* (Ashmead, 1895*)* (Hymenoptera; Figitidae) showed preference for *Palaeosepsis* spp. and *Triplasta coxalis* (Ashmead, 1865) (Hymenoptera; Figitidae) showed preference for *Palaeosepsis* spp. (X^2= 250,91; GL:77; P<0,05).

Regarding the preference of parasitoids for their hosts in bovine feces, it was found that *K. nigra* showed preference for *Palaeosepsis* spp.; *P. egeria* showed preference for *A. scabra* and *B. quadristigma*; *S. cameroni* showed preference for *B. debilis* and *Sarcophagula occidua* (Fabricius, 1794) (Diptera: Sarcophagidae); *S. drosophilae* showed preference for *B. quadristigma* and *S. occidua*; *S. endius* showed preference for *S. occidua; S. nigra* showed preference for *C. pararescita* and *S. occidua*; *S. nigroaenea* for *B. debilis*, *C. pararescita* and *S. occidua*; *Trichopria* sp. for *A. scabra* and *S. occidua*; *T. atrocoxalis* for *Palaeosepsis* spp. and *T. coxalis* for *Palaeosepsis* spp. (X^2= 146,12; P<0,05; GL:45) [8].

Figure 7 Map of Brazil: and their regions - Midwestern Region green color; Source: https://www.preparaenem.com/geografia/mapa-do-brasil.htm

3.7. Study 7

The aim of this study is to report the parasitoids collected on many substrates in the agroforestry area in Brazil.

The experimental study was carried out in an agroforestry area in the south of Goiás, Brazil. Traps made of metal containers (Figure 7). They are traps that are built with a metal container, painted externally with black matte paint, measuring about 20 cm in height and 9 cm in diameter, with two venetian openings, made in the lower third to allow the entry of insects.

Figure 8 General appearance of the trap

From 745 pupae of dipteran collected 684 parasitoids emerged from 111 pupae. The percentage of species collected in this study was: *Pachycrepoideus vindemmiae* (Rondani, 1875) (Hymenoptera: Pteromalidae) (25/684) with 3.7%, *Brachymeria podagrica* Fabricius, 1789 (Hymenoptera: Chalcididae) (68/684) with 10.0%, *Nasonia vitripennis* (Walker,

1836) (Hymenoptera: Pteromalidae) (231/684) with 33.8% and *Aphaereta* sp. (Hymenoptera: Braconidae: Alysiinae) (360/684) 52.6%. The most frequent species in this study was *Aphaereta* sp.

The number of parasitized pupae obtained the total percentage of parasitism / total number of pupae collected x 100. According to the formula, the total percentage of parasitism obtained at work was (111/745) 14.9%. The total percentage of parasitism obtained by the species in this study was *P. vindemmiae* (25/745) with 3.4%, *B. podagrica* (68/745) with 9.1%, *N. vitripennis* (10/745) with 0.9% and *Aphaereta* sp. (8/745) 1.1%. *Brachymeria podagrica* presented the highest total percentage of parasitism obtained by the species in this study.

The percentage of species collected in this study was: *P. vindemmiae* (25/684) with 3.7%, *B. podagrica* (Figure 8) with 10.0%, *N. vitripennis* 231/684) with 33.8% and *Aphaereta* sp. (360/684) 52.6%. The most frequent species in this study was *Aphaereta* sp. According to this formula *B. podagrica* was the species that presented the highest percentage of parasitism (11/20) with 55.0%, parasitizing *Ophyra aenescens* Wiedemann, 1830 (Diptera: Muscidae) on human feces substrate.

Figure 9 *Brachymeria podagrica* Fabricius, 1789 (Hymenoptera: Chalcididae); Source: https://bugguide.net/node/view/1675698

The number of parasitized pupae obtained the total percentage of parasitism / total number of pupae collected x 100. According to the formula, the total percentage of parasitism obtained at work was (111/745) 14.9%. The total percentage of parasitism obtained by the species in this study was *P. vindemmiae* (25/745) with 3.4%, *B. podagrica* (68/745) with 9.1%, *N. vitripennis* (10/745) with 0.9% and *Aphaereta* sp. (8/745) 1.1%. *Brachymeria podagrica* presented the highest total percentage of parasitism obtained by the species in this study [9].

3.8. Study 8

In this study, we tested (1) whether the current functional response of *Microctonus hyperodae* (Lloyd, 1966). (Hymenoptera: Braconidae) (Figure 9) to the density of its host pest, *Listronotus bonariensis* (Kuschel, 1955) (Coleoptera: Curculionidae), differs between two of the most common pasture grass species where parasitism rates have been shown to differ significantly in New Zealand agroecosystems, and (2) whether the functional response of *M. hyperodae* to *L. bonarensis* density has changed over the last 25 years, potentially being related to the changes in parasitism rates.

Figure 10 *Microctonus hyperodae* (Lloyd, 1966) (Hymenoptera: Braconidae) parasitizing *Listronotus bonariensis* (Kuschel, 1955) (Coleoptera: Curculionidae); Source: https://www.forestryimages.org/browse/detail.cfm?imgnum=1295012

We found that parasitism rates were significantly higher in *L. multiflorum* than in *Lolium perenne* L., 1753 (Poaceae) under the 2018 experimental conditions (p = 0.01, F = 7.8, df = 18). Also, overall parasitism rates were significantly higher in the 1993 experiment than in 2018 (p < 0.005, F = 31.5, df = 28).

We found no evidence in the 2018 data of any functional response in the *L. perenne* treatment. There was also a significant positive relationship between the slopes of the Type I functional responses in the *L. multiflorum* in 1993 and 2018 experiments (p < 0.005, R^2 = 0.62). We found no evidence of type II and III functional responses in any of the years or pasture types. However, we found a type I responses in *L. multiflorum* in both the historical 1993 data (p-value = 0.005, t = 3.14, slope = 0.38) and in 2018 data (p = 0.015, t = 3.07, slope = 0.16 [10].

3.9. Study 9

Thus, the objectives of this work were to evaluate the search behavior and *Hexacladia smithii* Ashmead, 1837 (Hymenoptera: Encyrtidae). Against stimuli from *Euschistus heros* (Fabr., 1794) (Heteroptera: Pentatomidae) (preferred host) and *Nezara viridula* (Linnaeus, 1758) (Hemiptera: Pentatomidae) and Study the effects of *H. smithii* parasitism on reproductive aspects of *E. heros.*

The parasitoid was preferentially attracted to the *E. heros* pheromone when contrasted with the control (hexane) (Wald = 4.52; p = 0.033). The pheromone treatment of this bug also resulted in longer residence time in the olfactometer arm that contained E. heros pheromone when compared to the hexane olfactometer arm (wilcoxon test W = 109; p = 0.014). The *N. viridula* pheromone was not attractive to the parasitoid, since there was no significant difference when evaluating the response of the parasitoid to the solution of this pheromone when contrasted with hexane (Wald = 1.74 gl = 19 p = 0.18). Similarly, there was no significant difference for the residence time of the parasitoid in the area of the olfactometer with *N. viridula* pheromone when compared to the area of the olfactometer with hexane (wilcoxon test W = 237; gl = 1; p = 0.32).

The longevity of parasitized *E. heros* females did not differ statistically from non-parasitized females (GLM analysis, t = -1.099 p = 0.277). Although there was a drop in survival of female E. heros parasitized at 15 days after parasitism, the survival curve did not show -200 -150 -100 -5 0 0 5 0 100 150 200 Eh Nv Control Treatment Residence time (sec) (20) (20) (20) (20) 106 significant differences between treatments (T = 2.840 p = 0.092). The total fecundity of *E. heros* females parasitized by *H. smithii* was lower when compared to non-parasitized females (GLM analysis, z = 5.38 p < 0.001). The non-parasitized females presented a daily fecundity fluctuation with an oviposition period longer than 30 days. For parasitized females, the oviposition rate significantly reduced from the tenth day on. When comparing fecundity in the first 15 days after parasitism, the number of eggs from parasitized females remained lower than that of non-parasitized females (GLM analysis, z = -3.21 p < 0.001) [11].

3.10. Study 10

Considering the importance that today *Euschistus heros* (Fabr., 1794) (Heteroptera: Pentatomidae) represents for the soybean crop, an attempt was made to know the occurrence of parasitism in this host. Parasitism in adults of *E. heros* was studied in weekly surveys carried out from November 1996 to December 1997, in the region of Londrina, PR, through random collections of 20 males and 20 females of the stink bug.

Hexacladia smithii Ashmead, 1837 (Hymenoptera: Encyrtidae) is a gregarious endoparasitoid of *E. heros* adults that spends the entire embryonic and post-embryonic development (larva and pupa) inside the host, being able to also attack the nymphs of the last instars. Adults, 1.5 to 2.0 mm in length are black, with male antennae pectin and female antennae filiform. The female of *H. smithii* lays internally in the abdomen of the stink bug, carrying out all the development of the parasitoids there. When they complete the cycle, about 35 days after parasitism, adults emerge through one or more holes, usually made on the ventral or dorsal surface of the abdomen. In *E. heros,* a variable number of parasitoids per host was found (two to 39 individuals), and in some cases, part of the progeny could emerge, while the rest remained inside, without completing development.

The natural incidence of parasitism by *H. smithii* ranged from 0.6% to 39.5%, with December and January being the time of greatest parasitoid abundance in the *E. heros* population. The population level was drastically reduced (<1%) during the period when the host is in partial hibernation (May to September). Of the total number of adults collected (2176 stink bugs), no difference was found in parasitism by *H. smithii* between males (14.7%) and females (11.9%) of *E. heros*, although fluctuations were recorded in the period [12].

4. Conclusion

Brazil is one of the few countries in the world that hold the so-called biological megadiversity, that is, important ecosystems, still healthy. This biodiversity can offer unique opportunity for pest control in both Brazil and other countries, due to the identification of new organisms with potential to be used in biological control.

For many agroecosystems in our country, little is known about the biodiversity and identity of species of natural enemies with the function of sustaining crop production. As a key component of global biodiversity and as a key determinant of sustainable agriculture, natural enemies should be better understood to be protected. Thus, biological control aims to reduce the population level of a species classified as a pest, keeping it below the level in which it is capable of causing economic harm.

Compliance with ethical standards

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