Study on the Hymenoptera parasitoid associated with Lepidoptera larvae in reforestation and agrosilvopastoral systems at Fazenda Canchim (Embrapa Pecuária Sudeste) São Carlos, SP, Brazil

A. G. Pereira[a], R. B. Silva[b], M. M. Dias[a] and A. M. Penteado-Dias[a]*

[a]Programa de Pós-graduação em Ecologia e Recursos Naturais, Departamento de Ecologia e Biologia Evolutiva – DEBE, Universidade Federal de São Carlos – UFSCar, CP 676, CEP 13565-905, São Carlos, SP, Brazil

[b]Departamento de Engenharia Ambiental e Sanitária – DEAS, Faculdades Santo Agostinho de Sete Lagoas – Fasasete, CEP 35701-281, Sete Lagoas, MG, Brazil

*e-mail: alinegpbio@yahoo.com.br

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Abstract

The aim of this study was to characterize the local fauna of Hymenoptera parasitoids associated with Lepidoptera larvae in areas of reforestation and agrosilvopastoral systems at Fazenda Canchim (Embrapa Pecuária Sudeste, São Carlos, SP, Brazil). Lepidoptera larvae collected with entomological umbrella were kept in the laboratory until emergence of adults or their parasitoids. From those collected in the agrosilvopastoral system, emerged 267 specimens of hymenopteran parasitoids belonging to 16 genera: Braconidae, Agathidinae (*Alabagrus*), Braconinae (*Bracon*), Microgastrinae (*Cotesia*, *Diolcogaster*, *Glyptapanteles*, *Pholetesor* and *Protapanteles*), Orgilinae (*Orgilus*); Ichneumonidae, Campopleginae (*Casinaria*, *Charops* and *Microcharops*); Chalcididae, Chalcidinae *(Brachymeria* and *Conura*); Eulophidae, Entedoninae (*Horismenus*), Eulophinae (*Elachertus* and *Euplectrus*). From the Lepidoptera larvae collected in the reforestation, emerged 68 specimens of hymenopteran parasitoids, belonging to 8 genera: Chalcididae, Chalcidinae (*Conura*); Ichneumonidae, Pimplinae (*Neotheronia*), Campopleginae (*Charops* and *Microcharops*) and Braconidae, Microgastrinae (*Apanteles*, *Diolcogaster*, *Distatrix*, *Glyptapanteles* and *Protapanteles*). The results of this study suggest the occurrence of a wide variety of Hymenoptera parasitoids in the studied environments.

Keywords: biodiversity, parasitoid, taxonomy.

Estudo dos Hymenoptera parasitoides associados a larvas de Lepidoptera em reflorestamento e sistema agrossilvipastoril na Fazenda Canchim (Embrapa Pecuária Sudeste), São Carlos, SP, Brasil

Resumo

O objetivo deste trabalho foi caracterizar a fauna local de Hymenoptera parasitoides associados a larvas de Lepidoptera em área de reflorestamento (corredor ecológico) e de sistema agrossilvipastoril na Fazenda Canchim (Embrapa Pecuária Sudeste, São Carlos, SP, Brasil). Larvas de Lepidoptera coletadas com guarda-chuva entomológico foram mantidas em laboratório até a emergência dos adultos ou de seus parasitoides. Daquelas coletadas no sistema agrossilvipastoril emergiram 267 espécimes de himenópteros parasitoides, pertencentes a 16 gêneros: Braconidae, Agathidinae (*Alabagrus*), Braconinae (*Bracon*), Microgastrinae (*Cotesia*, *Diolcogaster*, *Glyptapanteles*, *Pholetesor* e *Protapanteles*), Orgilinae (*Orgilus*); Ichneumonidae, Campopleginae (*Casinaria*, *Charops* e *Microcharops*); Chalcididae, Chalcidinae *(Brachymeria* e *Conura*); Eulophidae, Entedoninae (*Horismenus*), Eulophinae (*Elachertus* e *Euplectrus*). No reflorestamento emergiram 68 espécimes de himenópteros parasitoides, pertencentes a 8 gêneros: Chalcididae, Chalcidinae (*Conura*); Ichneumonidae; Pimplinae (*Neotheronia*), Campopleginae (*Charops* e *Microcharops*); Braconidae, Microgastrinae (*Apanteles*, *Diolcogaster*, *Glyptapanteles* e *Protapanteles*). Os resultados obtidos sugerem que os ambientes estudados abrigam grande diversidade de Hymenoptera parasitoides.

Palavras-chave: biodiversidade, parasitoide, taxonomia.

1. Introduction

The Hymenoptera are a key group to establish priorities for conservation, because they are sensitive to changes in land use and habitat quality and fulfill important ecological roles. Within this group, the parasitoids control the population of other insects that interfere in trophic chains of most agroecosystems (Perioto et al., 2004).

Many Lepidoptera are distinguished as pests that affect agricultural production, which stimulated researches in the areas of taxonomy and biology in order to use Hymenoptera parasitoids for biological control of these insects (Souza et al., 2006). This information becomes relevant when seeking recovery environmental indicators because the Hymenoptera have high diversity and can be easily sampled by a variety of methods. In an attempt to recover ecologically degraded landscapes and reduce the impacts of agricultural activities, new combinations of landscapes have emerged: agroforestry system and reforestation areas are recurrent examples of these new approaches. The composition of Hymenoptera parasitoids in these environments is poorly studied, especially regarding food plants of their host (Fernandes et al., 2010). Biodiversity inventories report the spatial distribution of biological elements (Kremen et al., 1993; Samways, 1993) and allow the characterization of the community that can be used in proposals for monitoring and conservation of environments (Longino and Colwell, 1997).

The aim of this study was to characterize the Hymenoptera parasitoids associated with Lepidoptera larvae collected from plants in area of reforestation and agrosilvopastoral system.

2. Material and Methods

The study was conducted at Fazenda Canchim, Embrapa Pecuária Sudeste, São Carlos, SP, Brazil (21° 55' S and 47° 48' W) from May 2010 to June 2012.

The Fazenda Canchim has approximately 2,538 hectares, of which 1,491 with pastures and experimental plots and 1,047 of permanent preservation areas and legal reserves. Climate is classified as a CWA-Awa (Köppen), with two distinct seasons: dry from April to September and the wet season from October to March. The average maximum and minimum temperatures are 26.8 and 15.6 °C, respectively. The annual relative humidity is 75.6% and the average altitude 850 m. The predominant soil is a typic dystrophic red latosol (Primavesi et al., 2008).

The reforestation system (R) has six hectares, with 51 different plant species. The agrosilvopastoral system (AS) has 12 hectares, including pastures and six species of native forest plants.

Samplings of larvae were made every two weeks from May 2010 to July 2012, using an entomological umbrella. Larvae of Lepidoptera collected were kept in the laboratory on host plants in individual plastic containers. The adults of the parasitoid Hymenoptera, as well as their pupae, the head capsules and debris of host larvae were preserved in 70% ethanol. The main literature sources used for the identification of Braconidae, Chalcididae and Ichneumonidae were Wharton et al. (1997), Gibson (1997) and Gauld (1991), respectively.

The Lepidoptera were identified by one of the authors of this work (M.M.D.). Parasitized larvae of Lepidoptera were identified using the head capsule and external morphology, besides comparison with photographic records.

The specimens of Lepidoptera and Hymenoptera were deposited at the Coleção Taxonômica do Departamento de Ecologia e Biologia Evolutiva, Universidade Federal de São Carlos, (DCBU). The plant samples were deposited at the Herbarium of Departamento de Botânica, Universidade Federal de São Carlos (HUFSCAR).

3. Results

During the sampling period, 129 Lepidoptera larvae were collected in reforestation (R), 14 of which were parasitized (10.8%). In agrosilvopastoral system (AS) 403 larvae of Lepidoptera were collected and 33 were parasitized (8.2%) (Table 1). Sampled plant species are at Table 2.

Species of Ichneumonidae (Campopleginae), Chalcididae (Chalcidinae) and Braconidae (Microgastrinae) occurred in the two sampling sites. The Braconidae (Agathidinae, Braconinae and Orgilinae) and Eulophidae (Entedoninae and Eulophinae) only occurred in the agrosilvopastoral system, while Ichneumonidae (Pimplinae) occurred only in reforestation (Table 2).

The Microgastrinae accounted for 64.58% of the total individuals captured in the two environments, followed by Entedoninae (9.23%), Chalcidinae (7.74%), Braconinae (7.14%), Eulophinae (5.65%), Campopleginae (4.17%), Agathidinae (0.60%), Orgilinae (0.60%) and Pimplinae (0.30%) (Table 2).

Considering the two systems, the most abundant species were gregarious, especially representatives of the subfamilies Chalcidinae, Microgastrinae, Entedoninae and Eulophinae (Table 2).

In reforestation were collected 65 specimens of four genera of Braconidae, six specimens of three genera of Ichneumonidae and seven specimens of three genera of Chalcididae (Table 2).

In the agrosilvopastoral system 189 specimens of Braconidae were collected of eight genera, nine specimens of Ichneumonidae of one genus, 50 specimens of Eulophidae of three genera and 19 specimens of Chalcididae of two genera (Table 2).

4. Discussion

The highest number of larvae was observed in the agrosilvopastoral system, however the percentage of parasitism was lower than that obtained in reforestation. The Microgastrinae were the most abundant in the two environments, however, presenting the largest number of

Table 1. Results of sampling of larvae collected in reforestation and agrosilvopastoral systems of Fazenda Canchim (Embrapa Pecuária Sudeste), São Carlos, SP, Brazil from May 2010 to July 2012.

Environment	Lepidoptera larvae collected	Parasitized larvae	
	(N)	(N)	(%)
Reforestation	129	14	10.8
Agrosilvopastoral	403	33	8.2

Table 2. Number of specimens and relative frequency of Hymenoptera obtained from Lepidoptera larvae collected in reforestation (R) and agrosilvopastoral systems (AS) at Fazenda Canchim (Embrapa Pecuária Sudeste), São Carlos, SP, Brazil, from May 2010 to July 2012.

Parasitoid (Hymenoptera)	Host (Lepidoptera)	R	AS	Host plant	Relative frequency (%)
BRACONIDAE					
Agathidinae					
Alabagrus sp.*	Olethreutinae Tortricidae	0	2	*Guazuma ulmifolia* Lam. Malvaceae	0.60
Braconinae					
Bracon sp.**	*Euglyphis* sp. Lasiocampidae	0	24	*Croton floribundus* Spreng. Euphorbiaceae	7.14
Microgastrinae					
Apanteles sp.*	*Lygropia unicoloralis* (Guenée,1854) Crambidae	1	0	*Aegiphila sellowiana* Cham. Lamiaceae	0.30
Cotesia sp1.**	*Memphis appias* (Hübner, [1825]) Nymphalidae	0	57	*Croton floribundus*	16.96
Diolcogaster sp1.*	Noctuidae	0	2	*Croton floribundus*	0.60
Diolcogaster sp2.*	Noctuidae	1	0	*Machaerium* sp. Fabaceae	0.30
Glyptapanteles sp1.**	*Bagisara paulensis* (Schaus, 1898) Noctuidae	0	1	*Croton floribundus*	0.30
Glyptapanteles sp2.**	*Thyrinteina arnobia* (Stoll,1782) Geometridae	10	29	*Croton floribundus*	11.61
Pholetesor sp.**	Saturniidae Hemileucinae	0	26	*Croton floribundus*	7.74
Protapanteles sp.**	*Glena* sp. Geometridae	43	46	*Trichilia hirta* L. Meliaceae	26.49
Orgilinae					
Orgilus sp.*	*Iridopsis sapulena* (Schaus, 1897) Geometridae	0	2	*Croton floribundus*	0.60
ICHNEUMONIDAE					
Campopleginae					
Casinaria sp1.*	Noctuidae	0	2	*Guazuma ulmifolia*	0.60
Casinaria sp2.*	Lepidoptera	0	1	*Anadenanthera colubrina* (Vell.) Brenan Fabaceae	0.30
Casinaria sp3.*	*Glena* sp. Geometridae	0	1	Anadenanthera colubrina	0.30
Casinaria sp4.*	*Apatelodes* sp. Apatelodidae	0	2	*Croton floribundus*	0.60
Casinaria sp5.*	*Bertholdia* sp. Noctuidae	0	1	*Croton floribundus*	0.30
Charops sp.*	Geometridae	1	0	*Machaerium* sp.	0.30

*Solitary Habit. **Gregarious Habit.

Table 2. Continued...

Parasitoid (Hymenoptera)	Host (Lepidoptera)	R	AS	Host plant	Relative frequency (%)
Microcharops sp1.*	*Euglyphis* sp.	3	2	*Nectandra megapotamica* (Spreng.) Mez Lauraceae	1.49
Microcharops sp2.*	*Euglyphis* sp.	1	0	*Vernonia rubriramea* Mart. ex DC. Asteraceae	0.30
Pimplinae					
Neotheronia sp.*	*Brachurapteryx breviaria* (Hübner, [1831]) Geometridae		0	*Croton floribundus*	0.30
CHALCIDIDAE					
Chalcidinae					
Brachymeria sp.**	*Brachurapteryx breviaria*		1	*Croton floribundus*	0.30
Conura sp1.**	*Brachurapteryx breviaria*		17	*Croton floribundus*	7.44
Conura sp2.*	*Brachurapteryx breviaria*		1	*Croton floribundus*	0.30
EULOPHIDAE					
Entedoninae					
Horismenus sp.**	*Memphis appias*	0	31	*Croton floribundus*	9.23
Eulophinae					
Elachertus sp.**	*Bagisara paulensis*	0	3	*Croton floribundus*	0.89
Euplectrus sp.**	*Bagisara paulensis*	0	16	*Croton floribundus*	4.76
Total		68	267		100.00

*Solitary Habit. **Gregarious Habit.

genera in the agrosilvopastoral system; this subfamily is cosmopolitan, highly diversified, comprising koinobiont endoparasitoids, solitary or gregarious on larvae of Lepidoptera (Mason, 1981; Whitfield et al., 2009). The other subfamilies of Braconidae occurred to a lesser extent, and included a variety of genera, mainly endoparasitoids of Lepidoptera larvae.

Specimens of *Alabagrus* sp. (Braconidae, Agathidinae) were found parasitizing larvae of Olethreutinae in agrosilvopastoral system. A similar study accomplished in the same area of this work observed *Apanteles* sp. on *Eupithecia* sp. in the agrosilvopastoral system (C. S. Souza, personal comm.), while in this work we have found this parasitoid on *Lygropia unicoloralis* in reforestation. According to Yu et al. (2012), no association of *Apanteles* spp. is known with *L. unicoloralis*, therefore this is the first report of the occurrence of this parasitoid on this host.

Other study in the same area using Malaise trap, has reported the occurrence of *Cotesia* sp. in all the studied environments (C. S. Souza, personal comm.) contrasting with the data found in this survey, where *Cotesia* sp. was found only in the agrosilvopastoral system. Salgado-Neto (2013) presented aspects of the biology of *Cotesia alius* (Muesebeck, 1958) on *Opsiphanes invirae amplificatus* Stichel, 1904 (Nymphalidae) in Brazil.

The present study observed the presence of *Diocolgaster* spp. in the two cultivation systems; the specimens emerged from larvae of Noctuidae (Lepidoptera). According to Yu et al. (2012), species of *Diolcogaster* was already observed in association with 90 items within 14 families of Lepidoptera, most species of Noctuidae. Tavares et al. (2012) studied the biological association of *Diolcogaster* sp. and *Agaraea minuta* (Schaus, 1892) (Arctiidae) on *Costus* spp. (Costaceae) in Brazil.

Glyptapanteles species were reported to the same area, associated with *Euphitecia* sp. (Geometridae), in the systems agrosilvopastoral and reforestation (C. S. Souza, personal comm.). This work, observed *Glyptapanteles* sp. in the same areas, but on *Bagisara paulensis* and *Thyrinteina arnobia*. There are no reports regarding association of *Glyptapanteles* spp. with these hosts (Yu et al., 2012) being this the first occurrence of this parasitoid on these Lepidoptera. *Glyptapanteles* species are solitary or gregarious parasitoids of macrolepidopterous larvae

(Mason, 1981), with a cosmopolitan distribution, very common and diversified (Whitfield et al., 2009). Braga et al. (2001) reported parasitism of *Glyptapanteles* sp. on *Eois tegularia* (Guenée, [1858]) (Geometridae); other study (L.B.R. Fernandes, personal comm.) has reported seven species of *Glyptapanteles*, one gregarious and six solitary associated with *Glena* sp., *Brachurapteryx breviaria*, *Semaeopus* sp. and *Hymenomima* sp. (Geometridae). Kenis et al. (2005) reported the association of *Glyptapanteles vitripennis* (Curtis, 1830) on young larvae of *Eupithecia lariciata* (Freyer, 1841) (Geometridae); Whitfield et al. (2009) recorded 94 occurrences of *Glyptapanteles* spp. on Lepidoptera of Ecuador, associated with species of the families Apatelodidae, Arctiidae, Geometridae, Limacodidae, Noctuidae, Nymphalidae, Pieridae, Pyralidae and Saturniidae. They reported that *Glyptapanteles* spp. associated to Limacodidae are unusual, but the other registered associations are typical of the genus in other regions.

There are several reports of the genus *Pholetesor* associated with Saturniidae (Wharton et al., 1997; Whitfield et al., 2009) in different areas and we have found this parasitoid on Saturniidae, Hemileucinae.

In this study, *Protapanteles* sp. was found in both areas on *Glena* sp. (Geometridae). It is a genus whose species are endoparasitoids of Lepidoptera larvae and species of Geometridae are the main hosts (Yu et al., 2012).

Marconato et al. (2008) reported parasitism of *Protapanteles* sp. on *Hymenomima amberia* (Schaus, 1901) and *Macaria regulata* (Fabricius, 1775) (Geometridae). Penteado-Dias et al. (2011) reported, the first occurrence in Brazil of *Protapanteles* (*Protapanteles*) *enephes* (Nixon, 1965) (Braconidae), associated with the larva of *Fountainea ryphea phidile* (Geyer, 1837) (Nymphalidae) in two deciduous forest fragments in São Carlos, SP.

There were reports of *Orgilus* sp. parasitizing larvae of *Iridopsis sapulena* (Schaus, 1897) (Geometridae); species of this family have been reported as hosts to Orgilinae in different areas (Braet and van Achterberg, 2001).

We have found *Casinaria* spp. parasitizing species of the families Geometridae (*Glena* sp.), Apatelodidae (*Apatelodes* sp.), Noctuidae (*Bertholdia* sp.). According to Yu et al., (2012) there were no reports about the genus *Casinaria* on these Lepidoptera, being the first occurrences of those associations. *Charops* sp. was found on larvae of Geometridae, only in reforestation area.

There are several reports of species of *Microcharops* associated to *Euglyphis* sp. (Gauld, 1991; Yu et al., 2012) and we found the same in this study.

The genus *Horismenus* Walker, 1843 was cited by Riley et al. (1894), Ashmead (1904) and Crawford (1911) as an important natural enemy hyperparasitoid on *Cotesia alius* (Muesebeck, 1958) (Braconidae, Microgastrinae) (Salgado- Neto and Di Mare, 2010; Salgado-Neto, 2013). This genus is predominantly a New World group, with its main distribution in the Neotropical region. The 400 described species are parasitoids or hyperparasitoids on a variety of hosts, most commonly on larvae of Coleoptera, Diptera and Lepidoptera (Hansson, 2009). Records includes both solitary or gregarious species, specialist or generalist parasitoids, and as far as is known all are endoparasitoids and presumably koinobionts (Hansson et al., 2011).

Elachertus sp. and *Euplectrus* sp. parasitizing larvae of *Bagisara paulensis* (Noctuidae) were found in the agrosilvopastoral system; other species of this family of Lepidoptera were reported as hosts of Eulophinae by other authors (Zhu and Huang, 2003).

The diversity of Hymenoptera can be increased by the greater availability of food resources for parasitoids, as hosts for their immature stages and increased diversity of the surrounding vegetation (Altieri and Letourneau, 1982; Altieri et al., 1984; Campos and Cure, 1993). The results suggest that the studied environments present a great diversity of Hymenoptera parasitoids, due to a greater availability of food resources for them and also for their hosts. Thus, reforestation practices and mixed systems of environment utilization should be encouraged. New studies on the interactions of plant-host-parasitoid may assist the monitoring of the distribution of the species involved in landscape structure.

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