

Ichneumonids (Hymenoptera) and Tachinid Flies (Diptera) Associated to Lepidopterans in Soybean Crops

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Abstract

Studies on natural enemies are important to find new species and to develop management strategies to preserve them to help control pests in biological control programs. For the state of Mato Grosso, Brazil, which comprises the Amazon, Cerrado, and Pantanal biomes, few studies have been conducted on the diversity of these parasitoids, possible endemic and/or new species, as well as their potential as natural enemies. Thus, the present study was aimed at describing the diversity of parasitoids of the families Ichneumonidae (Hymenoptera) and Tachinidae (Diptera) associated with pest lepidopterans in soybean crops. Weekly sampling of pest lepidopterans was carried out during four soybean seasons (2009/2010, 2010/2011, 2011/2012 and 2012/2013). Parasitoid larvae were observed in the main lepidopteran pest species of soybean during the four soybean seasons. Three genera of the Ichneumonidae family, belonging to the genera *Microcharops* Roman, *Ophonellus* Westwood, and *Podogaster* Brullé. Six genera of the Tachinidae family occur in the state of Mato Grosso in soybean fields. The following genera were recorded: *Archytas* spp. Jaenicke, *Phorocera* spp. Robineau-Desvoidy, *Gymnocarcelia* spp. Townsend, *Lespesia* spp. Robineau-Desvoidy, *Eucelatoria* spp. Townsend, *Chetogena* spp. Rondani. These parasitoids were found parasitizing caterpillars of the Noctuidae (Lepidoptera), in species that had not yet been reported as hosts for the Neotropical region. Further studies are needed on the beneficial entomofauna and their preservation in agricultural environments.

Keywords: *Microcharops*, *Ophonellus*, *Podogaster*, *Archytas*, *Lespesia*, *Eucelatoria*

1. Introduction

Soybean (*Glycine max* L.) is the main crop of the Brazilian agribusiness, covering an area of 33.9 million hectares. The 2016/2017 crop totaled 114 million tons of soybeans, with the state of Mato Grosso as the largest producer, accounting for approximately 27% of this total (CONAB, 2017). However, phytosanitary problems in the state, such as pest lepidopterans that attack leaves and pods, reduce the production and the quality of soybeans. In general, chemical control is carried out, often not selective to natural enemies, reducing their population and increasing pest unbalance. Knowledge on the natural enemies associated with phytophagous insects of soybean plants is still scarce, especially regarding biological agents associated with pest lepidopterans, such as wasps of the family Ichneumonidae (Hymenoptera) and flies of the family Tachinidae (Diptera).

Among parasitoids of lepidopteran larvae, the Ichneumonidae family is of special interest. It is one of the largest insect families comprised of an estimated 100.000 species (Gauld, 2002). The Tachinidae is the second largest family of parasitic flies, with approximately 10.000 described species (Stireman III et al., 2006), and also includes parasitoids of lepidopterans. Studies on their hosts, behavior, and habitats of species of this family have been carried out in more detail in Europe (Stireman III et al., 2006), while other studies addressed the potential of tachinid flies (Simões et al., 2002). However, few records are available for parasitoids of this family in Brazil, and none exist for the state of Mato Grosso. The diversity of these parasitoids is influenced by the local

biodiversity and the environment surrounding the agroecosystem, as well as management practices (Chay-Hernandez et al., 2006).

In monocultures, studies tend to underestimate the diversity of parasitoid species, since host diversity will also be limited in a crop (Altieri et al., 2003). In addition, natural enemies are less frequent in annual crops, because each year they need to recolonize the area after the off-season, except where conditions allow the maintenance of species. Despite that, studies on natural enemies are especially important to find new species and to develop management strategies to preserve them to help control pests in biological control programs. For the state of Mato Grosso, which comprises the Amazon, Cerrado, and Pantanal biomes, few studies have been conducted on the diversity of these parasitoids, possible endemic and/or new species, as well as their potential as natural enemies. Thus, the present study was aimed at describing the diversity of parasitoids of the families Ichneumonidae and Tachinidae associated with pest lepidopterans in soybean crops.

2. Material and Methods

Weekly sampling of pest lepidopterans was carried out during four soybean seasons (2009/2010, 2010/2011, 2011/2012 and 2012/2013) from December to February of each year in the municipality of Tangará da Serra, MT (14°18'44"S and 57°45'18"W).

The sampling methods used were beat sheet (20 sheets per hectare) and visual search for 2 hours. Specimens were stored in plastic containers (145 ml) and taken to the Laboratory of Entomology of the Research Center for Agro-Environmental Development of the State University of Mato Grosso, campus of Tangará da Serra, MT. In the laboratory, caterpillars were classified with the aid of an identification guide (Sosa-Gómez et al., 2010) and placed in individual tubes. Specimens collected during the first three growing seasons were fed a natural diet (soybean leaves), while those collected during the last crop were fed an artificial diet (Greene et al., 1976). Caterpillars were monitored daily to check of parasitism. Newly emerged parasitoids were preserved in 70% ethanol and then identified at the lowest taxonomic level possible.

3. Results

Parasitoid larvae were observed in the main lepidopteran pest species of soybean during the four soybean seasons (Tables 1 and 2).

3.1 Ichneumonid Parasitoids (Hymenoptera)

In the first season (2009/2010), 401 caterpillars were collected and none showed signs of parasitism by ichneumonid wasps. In the 2010/2011 season, 367 caterpillars were sampled and six specimens had parasitoids from this family. In the following season (2011/2012), 1948 caterpillars were collected and only one was parasitized. In the 2012/2013 season, 498 caterpillars were collected and seven were parasitized (Table 1).

Table 1. Species of Noctuidae (Lepidoptera) sampled during soybean season and their parasitoids of the family Ichneumonidae (Hymenoptera) in Tangará da Serra, MT

Season	Host	Subfamily/Genus	N°
2009/2010	No parasitoids of this family were recorded		0
2010/2011	<i>Chrysodeixis includens</i>	Campopleginae/ <i>Microcharops</i> sp.	1
		Anomaloniinae/ <i>Ophionellus</i> sp.	4
		Anomaloniinae/ <i>Podogaster</i> sp.	1
2011/2012	<i>Chrysodeixis includens</i>	Anomaloniinae/ <i>Ophionellus</i> sp.	1
2012/2013	<i>Chloridea virescens</i>	Anomaloniinae/ <i>Ophionellus</i> sp.	5
		<i>Spodoptera cosmioides</i>	Unidentified
Total parasitoids			14

The parasitoids sampled belonged to the genera *Microcharops* Roman, *Ophionellus* Westwood, and *Podogaster* Brullé, representing two subfamilies: Campopleginae, recorded only in the 2010/2011 season and Anomaloniinae, in the three crops examined.

In the first and second seasons, Ichneumonid wasps were only found in the host species *Chrysodeixis includens* (Walker) (Lepidoptera: Noctuidae). In the third season, parasitism was observed in *Chloridea virescens* (Fabricius) (Lepidoptera: Noctuidae), and *Spodoptera cosmioides* (Walker) (Lepidoptera: Noctuidae), although the number of parasitized *C. includens* caterpillars sampled was higher than those of other species. Of the 498

caterpillars collected, 329 were identified as *C. includens*, 85 *C. virescens*, 69 *Spodoptera* sp., and 15 *Anticarsia gemmatalis* Hübner (Lepidoptera: Noctuidae). This is the first record of the occurrence of the genus *Ophionellus* sp. parasitizing *C. includens* and *C. virescens* in Brazil.

3.2 Tachinid Parasitoids

Tachinid flies parasitizing caterpillars of soybeans are reported here for the first time for the state of Mato Grosso. Of the 401 caterpillars collected in the first season (2009/2010), five were parasitized by tachinid flies. In the next season (2010/2011), 12 caterpillars were parasitized from a total of 367 collected. In the 2011/2012 season, of the 1948 caterpillars sampled, five were parasitized. In the last growing season (2012/2013), of the 498 caterpillars collected, eight parasitoids of this family were recorded (Table 2).

Table 2. Species of Noctuidae (Lepidoptera) sampled during four soybean seasons and their parasitoids of the family Tachinidae (Diptera) in Tangará da Serra, MT

Season	Host	Subfamily/Tribe/Genus	N°	
2009/2010	<i>Anticarsia gemmatalis</i>	<i>Archytas</i> spp.	2	
		<i>Phorocera</i> sp.	1	
		Unidentified	1	
	<i>Chrysodeixis includens</i>	Tribe Blondeliini	1	
2010/2011	<i>Chrysodeixis includens</i>	<i>Lespesia</i> spp.	2	
		<i>Eucelatoria</i> spp.	3	
		<i>Archytas</i> spp.	4	
		<i>Spodoptera</i> sp.	<i>Eucelatoria</i> spp.	2
		Unidentified caterpillar	<i>Gymnocarcellia</i> sp.	1
2011/2012	<i>Chrysodeixis includens</i>	Unidentified	5	
2012/2013	<i>Chrysodeixis includens</i>	<i>Lespesia</i> spp.	5	
		<i>Phorocera</i> sp.	1	
		<i>Chetogena</i> sp.	1	
		Unidentified	1	
Total parasitoids			30	

Tachinid parasitoids are difficult to identify, mainly due to the low number of specimens usually obtained. In this study, specimens of the Tribe Blondeliini and of the following genera were recorded: *Archytas* spp. Jaenicke, *Phorocera* spp. Robineau-Desvoidy, *Gymnocarcellia* spp. Townsend, *Lespesia* spp. Robineau-Desvoidy, *Eucelatoria* spp. Townsend, *Chetogena* spp. Rondani. Some specimens could only be identified at the family level (Table 2).

4. Discussion

The occurrence and diversity of insects of agricultural importance in a region are associated with the density and biodiversity of existing hosts (Onody, 2005). Studies on the entomofauna are important to expand the knowledge on the biodiversity of agroecosystems and to provide a framework for integrated pest management, since several beneficial insects, such as ichneumonid and tachinid parasitoids, can be used in biological control.

In the present study, ichneumonids were found parasitizing species in soybean fields, which had not yet been reported in Brazil. The low number of parasitoids compared to the number of caterpillars collected may have occurred because soybean is an annual crop and parasitoids need to recolonize the area every growing season. In addition, extensive areas planted with soybean and low plant diversity in the environment may also contribute to decrease the diversity and abundance of natural enemies (Hooks & Johnson 2003; Lavandero et al., 2006; Shennan, 2008). Another factor to be considered is the type of management practices. The conventional practices in the study area uses chemical products that often follow a predetermined schedule regardless of pest density (control level). Also, a mixture of pesticides may be used and cause a “hitchhiking effect”, which can be harmful to ichneumonids, as well as to other beneficial agents (Bueno et al., 2012).

Few studies have been conducted on ichneumonids in the neotropics, such as those by Gauld (1991, 1997), Lanfranco (1974a, 1974b), Jerez et al. (1977), Porter (1975, 1979). In Brazil, ichneumonids have been reported in geometrid caterpillars (Lepidoptera) collected in areas of Cerrado in São Carlos, SP (Braga et al., 2001;

Marconato et al., 2008), while Kumagai and Graf (2000), in Curitiba, PR, and Kumagai (2002) in Belo Horizonte, MG, collected ichneumonids using flight interception traps, among other studies (Sandonato et al., 2010; Onody & Penteado-Dias, 2016).

Ichneumonid parasitoids from two subfamilies were collected: Campopleginae, recorded only during the first growing seasons, and Anomaloniinae, in the three crops examined. Campopleginae parasitoids are important in the control of insect populations and their larvae are cenobiont endoparasitoids, mainly of caterpillars, which are widely known as agricultural pests (Onody, 2005; Sandonato et al., 2010). In the Neotropical region, 21 genera of Campopleginae have been recorded and of these, 18 occur in Brazil (De Santis, 1980; Graf & Kumagai, 1997; Kumagai & Graf, 2000; Yu et al., 2012; Onody & Penteado-Dias, 2006). While Anomaloniinae is a cosmopolitan subfamily and includes cenobiont endoparasitoids of lepidopteran larvae and coleopteran, sixteen genera of this subfamily occur in the neotropical region and seven in Brazil (Yu et al., 2012). Tachinid flies are endoparasitoids that have insects of eight orders as hosts (Wood & Zumbado, 2010).

In Lepidoptera, tachinid flies are naturally occurring beneficial agents with potential for biological pest control (Stireman et al., 2006; Nihei & Pavarini, 2011). Although tachinid flies comprise more than 1.500 known genera (O'Hara, 2012), only six have been recorded in this study. The genus *Archytas* has approximately 15 species, with native flies from North America and South America (Elliott et al., 2017). They are parasites of several families of lepidopterans such as Noctuidae, Notodontidae, Arctiidae, Lasiocampidae, among others (Tachinidae Resources, 2017). *Archytas* sp. (Lepidoptera: Noctuidae) has been recorded in soybean fields in the state of Minas Gerais, Brazil (Lopes-da-Silva et al., 2014), confirming that this genus is associated with caterpillars of this crop in Brazil. *Lespesia* is one of the largest and most important of Tachinidae, with 66 known species, of which 37 occur in the neotropical region (Toma, 2010). Records indicate that their hosts include the families Noctuidae, Notodontidae, Saturniidae, and Sphingidae (Wood & Zumbado, 2010), but studies conducted in South America are still scarce (Gil-Santana et al., 2014). *Chetogena* consists of 22 species known to occur in the neotropics (Nihei, 2015), including endoparasitoids that attack several groups of insects and mainly several families of Lepidoptera (Sourovkov & Mitchell, 2002; Stireman & Singer, 2003a, 2003b). *Eucelatoria*, on the other hand, is a genus that cluster parasites of lepidopterans of the Noctuidae family, especially of the genus *Chloridea*, *Spodoptera*, *Pseudaletia*, *Leucania*, *Mocis*, *Trichoplusia* and occasionally other lepidopteran families (Sabrosky, 1981). And the genus *Gymnocarcelia* comprises species of parasites used in biological control programs in forestry management, fruticulture, horticulture, and other agricultural crops, parasitizing insect species of various orders such as Hemiptera, Orthoptera, Lepidoptera and Coleoptera (Sánchez-Arias et al., 2017).

Worldwide, there is a high diversity of tachinid flies, however, species identification is difficult, especially in the west. Inclán and Stireman (2014) point out that the tropics of the New World are the most diverse region for tachinid parasitoids, but also have the most closely defined genera of tachinids as well as the most confusing ones of any biogeographic region. Thus, the species found in the present study were identified at the genus level. Further studies are needed to provide in-depth knowledge on the Brazilian tachinid species with potential use in pest control. The natural occurrence of parasitoids in agroecosystems is essential to assist the control of pest populations and consequently reduce yield losses. Menezes (2005) points out that biological control programs require the maintenance of natural enemies in the agroecosystem by preserving and managing habitats, and providing conditions for their survival and reproduction. However, in order to develop these programs, knowledge on the composition and behavior of local natural enemies is needed.

We conclude that three genera of the Ichneumonidae family and six genera of the Tachinidae family occur in the state of Mato Grosso in soybean fields. These genera were found parasitizing caterpillars of the Noctuidae family, in species that had not yet been reported as hosts for the Neotropical region. Further studies are needed on the beneficial entomofauna and their preservation in agricultural environments.

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