

Coccinellidae Parasitoids in Brazil: Neglected Species in a Mega-Diverse Country

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Abstract

Current knowledge on coccinellids is primarily focused on their role as natural enemies of soft-bodied insects. However, there is a great diversity of coccinellid parasitoid species that are less studied. Here, we describe new records of coccinellid parasitoids with emphasis on new host–parasitoid interactions in 11 sample sites in Brazil. We collected 122 coccinellid individuals parasitized by six species of parasitoids in the Cerrado and in the Atlantic Rainforest biomes. New records of coccinellid parasitoids and host associations, expansion of habitat ranges and interactions are discussed focusing on the lack of basic information on these interactions in Brazil.

Coccinellids are one of the most studied group of predators of soft-bodied insects worldwide (Michaud 2012). They are part of complex food webs acting at the same time as predators, competitors, intraguild predators and prey (Lucas 2012). The knowledge on these predator species and their interactions is widespread, but information on their parasitoid species are less studied and understood. So far, there are nearly 100 known coccinellid parasitoid species (Riddick *et al* 2009), and although the diversity of parasitoids of coccinellids is still growing, the records are concentrated in temperate regions such as Europe, Japan and the USA (Ceryngier *et al* 2012).

Therefore, there are only a few records of coccinellid parasitoid species in tropical and mega-diverse regions. In Brazil, for example, the few records available were made by Gravena (1978), Berti-Filho & Costa (1995) and Silva *et al* (2012). Here, we describe new records of coccinellid parasitoids with emphasis on new host–parasitoid interactions in

two biomes considered hotspots of biodiversity in Brazil. The information we provide highlights the lack of basic information on coccinellid parasitoids in this mega-diverse country.

The study was conducted in agricultural areas in Brazil, four of them in the state of Minas Gerais and seven in the Federal District, from November 2008 to December 2011 (Table 1). Collection sites in Minas Gerais were located in the Zona da Mata, a region in the Atlantic Rainforest biome. The region has a tropical highland climate with an average temperature of 19°C and an average precipitation of 1800 mm per year. The collection sites in the Brazilian Federal District were located in the Central Plateau region in the core of the Cerrado biome, the Brazilian tropical savanna. The climate in this location is semi-humid with mean temperatures ranging from 22 to 27°C, an average rainfall of 1200 mm per year and a marked dry season (Klink & Machado 2005).

Table 1 Coccinellids parasitized by distinct species of parasitoids collected in different regions and habitats in Brazil, 2008–2011.

Parasitoid taxon	City, state*	Collection sites	Geographical Coordinates	Parasitized coccinellids
Hymenoptera				
Braconidae				
<i>Dinocampus coccinellae</i>	Viçosa, MG	Multiple crops	20° 45' 14" S, 42° 52' 54" W	<i>Cycloneda sanguinea</i> ; <i>Coleomegilla maculata</i>
	Viçosa, MG	Orchard	20° 45' 14" S, 42° 52' 54" W	<i>Cycloneda sanguinea</i>
	Piranga, MG	Pumpkin crop	20° 45' 4" S, 43° 18' 10" W	<i>Cycloneda sanguinea</i>
	Piranga, MG	Chilli pepper crop	20° 45' 4" S, 43° 18' 10" W	<i>Cycloneda sanguinea</i>
	Brasília, DF	Genetically modified cotton	15° 43' 37" S, 47° 57' 56" W	<i>Cycloneda sanguinea</i>
	Taguatinga, DF	Organic vegetable crops	15° 49' 48.5" S, 48° 04' 13.4" W	<i>Cycloneda sanguinea</i>
	Samambaia, DF	Organic vegetable crops and agroforestry	15° 50' 41" S, 48° 4' 26" W	<i>Cycloneda sanguinea</i>
	Rajadinha, DF	Organic vegetable crops	15° 45' 44.9" S, 47° 38' 28.9" W	<i>Cycloneda sanguinea</i>
	Ceilândia, DF	Organic vegetable crops and agroforestry	15° 49' 31.2" S, 48° 15' 6" W	<i>Cycloneda sanguinea</i>
Brazlândia, DF	Organic strawberry crop	15° 40' 21.96" S, 48° 09' 52.39" W	<i>Harmonia axyridis</i>	
Eulophidae				
<i>Aprostocetus</i> sp.	Brasília, DF	Genetically modified cotton	15° 43' 37" S, 47° 57' 56" W	<i>Cycloneda sanguinea</i>
	Brasília, DF	Agroforestry	15° 43' 48" S, 47° 54' 1" W	<i>Cycloneda sanguinea</i>
Encyrtidae				
<i>Homalotylus terminalis</i>	Brasília, DF	Agroforestry	15° 43' 48" S, 47° 54' 1" W	<i>Cycloneda sanguinea</i>
	Brazlândia, DF	Organic strawberry crops	15° 40' 21.96" S, 48° 09' 52.39" W	<i>Hippodamia convergens</i>
	Samambaia, DF	Organic vegetable crops and agroforestry	15° 49' 31.2" S, 48° 15' 6" W	<i>Cycloneda sanguinea</i>
	Taguatinga, DF	Organic vegetable crops	15° 49' 48.5" S, 48° 04' 13.4" W	<i>Cycloneda sanguinea</i>
	Ceilândia, DF	Organic vegetable crops and agroforestry	15° 49' 31.2" S, 48° 15' 6" W	<i>Cycloneda sanguinea</i>
Pteromalidae				
<i>Pachyneuron aphidis</i>	Brasília, DF	Genetically modified cotton	15° 43' 37" S, 47° 57' 56" W	<i>Cycloneda sanguinea</i>
	Brasília, DF	Agroforestry	15° 43' 48" S, 47° 54' 1" W	<i>Cycloneda sanguinea</i>
Diptera				
Tachinidae				
<i>Strongygaster brasiliensis</i>	Viçosa, MG	Multiple crops	20° 45' 14" S, 42° 52' 54" W	<i>Cycloneda sanguinea</i> ; <i>Harmonia axyridis</i>
	Piranga, MG	Chilli pepper crop	20° 45' 4" S, 43° 18' 10" W	<i>Cycloneda sanguinea</i>
	Brazlândia, DF	Organic strawberry crop	15° 40' 21.96" S, 48° 09' 52.39" W	<i>Harmonia axyridis</i>
Phoridae				
<i>Phalacrotophora netae</i>	Brasília, DF	Agroforestry	15° 43' 48" S, 47° 54' 1" W	<i>Cycloneda sanguinea</i>

*MG Minas Gerais, DF Federal District.

Larvae, pupae and adults of coccinellids were collected during 1 week per month, except in the field where trials with genetically modified cotton were performed in the Federal District. Coccinellids were collected in a fortnightly basis during the cotton crop season from November/2008 to February/2009 and from November/2009 to February/2010. Insects were collected directly over randomly selected plants during 2 h per day in each sample site. Samples were focused mainly on *Cycloneda sanguinea* L. (Coleoptera: Coccinellidae) in order to establish a stock rearing of this species in the laboratory for further bioassays.

Nevertheless, other coccinellids were occasionally sampled, such as *Coleomegilla maculata* (DeGeer) and *Harmonia axyridis* (Pallas), and were collected as well.

Field-collected individuals were taken to the laboratory (25±1°C, 75% RH). Adults were coupled, fed with the laboratory-reared aphids *Aphis gossypii* Glöver and *Myzus persicae* (Sulz.), and kept inside plastic pots (500 mL). Field-collected larvae and pupae were individualized in plastic pots (50 mL), and larvae were fed with the same diet provided to the adults. Samples were checked twice a week and the food sources replaced ad libitum. When symptoms of

parasitization were detected (e.g. immobility or death), coccinellids were kept separated until parasitoid emergency. The number of parasitoids that emerged per host was recorded. Hymenopteran parasitoids were identified by one of us (VAC), while dipteran parasitoids were sent to other taxonomists for species identification. Voucher specimens were deposited in the following institutions: Centro Experimental do Instituto Biológico (all Hymenoptera species), Departamento de Zoologia in the Universidade de Brasília (Tachinidae species) and Universidade de São Paulo (Phoridae species).

We collected a total of 122 individuals (larvae, pupae and adults) comprising four species of coccinellids parasitized by six species of parasitoids in agricultural areas in the Cerrado and in the Atlantic Rainforest biomes (Table 1). Adult coccinellids were parasitized by the solitary parasitoid *Dinocampus coccinellae* (Schrank) (Hymenoptera: Braconidae) and *Strongygaster brasiliensis* (Towsend)

(Diptera: Tachinidae). *Dinocampus coccinellae* was the most abundant in our samples (30% from all parasitized individuals collected; 59.4% of all adult coccinellids parasitized) and they were found in all sample sites, except in the agroforestry, parasitizing three species of adult coccinellids (Tables 1 and 2). *Strongygaster brasiliensis* was recorded in only three sample sites (Table 1) associated with two coccinellid species (Table 2), and comprised 40.61% of the adult coccinellids parasitized. The gregarious *Phalacrotophora nedae* (Malloch) (Diptera: Phoridae) was the only species parasitizing a coccinellid pupa, and it was collected in just one habitat type (Tables 1 and 2), being the least abundant in our samples (2.5% from all collected coccinellid parasitoids) (Tables 1 and 2).

Three species of gregarious larval parasitoids were recorded on two species of coccinellids (Table 1). *Homalotylus terminalis* (Say) (Hymenoptera: Encyrtidae) was found in four habitats parasitizing larvae of two species of coccinellids, while *Pachyneuron aphidis* (Bouché) (Hymenoptera:

Table 2 Species of coccinellid parasitoids that parasitized different developmental stages of their hosts and mean number (\pm SD) of parasitoids per host collected in different regions and habitats in Brazil, 2008–2011.

Parasitoid taxon	Host	Host stage	Individuals parasitized	Number of parasitoids emerged from each host (min–max)	Parasitoid classification	New interactions*
Hymenoptera						
Braconidae						
<i>Dinocampus coccinellae</i>	<i>Cycloneda sanguinea</i>	Adult	36	1	Solitary	First record in the Brazilian Atlantic Rainforest and first record parasitizing <i>H. axyridis</i> in Brazil
	<i>Coleomegilla maculata</i>	Adult	1	1	Solitary	
	<i>Harmonia axyridis</i>	Adult	1	1	Solitary	
Eulophidae						
<i>Aprostocetus</i> sp.	<i>Cycloneda sanguinea</i>	Larvae	9	4.0 \pm 1.94 (1–6)	Gregarious	First record parasitizing <i>C. sanguinea</i> and first record parasitizing coccinellids in South America
Encyrtidae						
<i>Homalotylus terminalis</i>	<i>Cycloneda sanguinea</i>	Larvae	27	4.7 \pm 1.77 (1–8)	Gregarious	First record in Brazil and first record parasitizing <i>H. convergens</i> in Brazil
	<i>Hippodamia convergens</i>	Larvae	2	3.0 \pm 1.41 (2–4)	Gregarious	
Pteromalidae						
<i>Pachyneuron aphidis</i>	<i>Cycloneda sanguinea</i>	Larvae	17	4.9 \pm 2.59 (1–13)	Gregarious	First record parasitizing coccinellids in Brazil. First record parasitizing <i>C. sanguinea</i>
Diptera						
Tachinidae						
<i>Strongygaster brasiliensis</i>	<i>Cycloneda sanguinea</i>	Adult	21	1	Solitary	New coccinellid parasitoid and first record parasitizing <i>C. sanguinea</i> and <i>H. axyridis</i>
	<i>Harmonia axyridis</i>	Adult	5	1	Solitary	
Phoridae						
<i>Phalacrotophora nedae</i>	<i>Cycloneda sanguinea</i>	Pupae	3	3.0 \pm 1.73 (1–4)	Gregarious	First record in the Cerrado biome

*New interactions refer to new records related to each parasitoid species.

Pteromalidae) and *Aprostocetus* sp. (Hymenoptera: Eulophidae) were found in only two habitats on one coccinellid species (Tables 1 and 2). *Homalotylus terminalis* was the most abundant larval parasitoid (52.7% from the parasitized larvae) followed by *P. aphidis* (30.9%) and *Aprostocetus* sp. (16.4%).

The record of *D. coccinellae* on *H. axyridis* is the first for Brazil, and its low abundance in our sampling is probably due to the recent arrival of *H. axyridis* in our sample site areas (Rezende et al 2010, Harterreiten-Souza et al 2012) and to our preferential sampling of *C. sanguinea*.

Strongygaster brasiliensis has been recorded on coleopteran (Guimarães 1978, Mikami & Ventura 2008) and hemipteran (Guimarães 1977) hosts in Brazil, but our records are the first on coccinellids as hosts for this species. Coccinellids are known as hosts for the genus *Strongygaster*, as several records are available for *Strongygaster triangulifera* (Loew) in North America (Ceryngier et al 2012, O'Hara 2014).

Phalacrotophora nedae was previously recorded parasitizing other coccinellids exclusively in South America, including *C. sanguinea* in Brazil (Gravena 1978). Nevertheless, our record extends its geographical range as it is the first for this species in the Cerrado biome.

More than half of the known species of *Homalotylus* parasitizes coccinellids or has some association with coccinellids (Ceryngier et al 2012), but our records for *H. terminalis* are the first for this species in Brazil and it is the first for its association with *Hippodamia convergens*. Previous records of this species were made in North and Central America, Guyana and Uruguay parasitizing mainly Coccinellinae, including *C. sanguinea* (Noyes 2014).

Pachyneuron aphidis was collected in only two sample sites in the Cerrado biome parasitizing *C. sanguinea*. There are only six species of this genus recorded in association with coccinellids, which are presumably secondary parasitoids (Ceryngier et al 2012). Most of their host species are Aphididae, but they also parasitize other Hemiptera, Coleoptera, Diptera and Lepidoptera species and are recorded as secondary parasitoids of Aphelinidae, Braconidae (Aphidiinae), Encyrtidae, Figitidae (including Charipinae) and Platygastridae (Noyes 2014). We are sure that *P. aphidis* was parasitizing *C. sanguinea* larvae because we isolated parasitized coccinellids and fed the larvae with aphids reared in controlled conditions (free of aphid parasitoids). Thus, this is the first record of this species parasitizing *C. sanguinea* and the first record of a *Pachyneuron* species parasitizing coccinellids in Brazil.

It was not possible to identify the species of *Aprostocetus* specimens because there are no keys for the New World fauna and systematics of this genus is problematic. They were found in the same habitats and parasitizing the same

host of *P. aphidis* (Table 1). *Aprostocetus neglectus* Domenichini and *Aprostocetus esurus* Riley are the only two species of *Aprostocetus* recorded parasitizing coccinellids, and they are usually secondary parasitoids (Ceryngier et al 2012). In our study, we found one adult of *Aprostocetus* sp. that emerged together with three *H. terminalis* adults from the same coccinellid larva. As some species of *Aprostocetus* are recognized as secondary parasitoids (Noyes 2014), we presume that they were using *C. sanguinea* as secondary hosts.

Our study demonstrated an unknown diversity of interactions between coccinellids and parasitoids, even while sampling in agricultural lands in only two biomes in Brazil. Coccinellid parasitoids occur in a wide variety of habitats and can interact with several species of coccinellids. This implies that the occurrence of these species in Brazil is probably largely underestimated or even neglected. Our records will also allow the development of future studies on new host–parasitoid interactions.

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