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Sección Básica

Seasonal damage caused by herbivorous insects on *Caryocar brasiliense* (Caryocaraceae) trees in the Brazilian savanna

Daños causados por insectos herbívoros en los árboles de *Caryocar brasiliense* (Caryocaraceae) en la sabana brasileña

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Abstract: *Caryocar brasiliense* (Caryocaraceae) trees have a wide distribution in the Brazilian savanna. This plant is protected by federal laws and is untouched in deforested areas of the Brazilian savanna**.** This situation increases the damage to leaves, flowers, and fruits from chewing insects. We studied populations of herbivorous Lepidoptera, Coleoptera, and Hymenoptera and their natural enemies on *C. brasiliense* trees for three successive years during each season in the Brazilian savanna. Phytophagous insects were most abundant at the beginning of winter and with more species and diversity in the summer. Natural enemies were most abundant in the spring and in the winter and with highest species and diversity at end of the winter. Fruits bored by *Carmenta* sp. (Lepidoptera: Sesiidae) and *Naupactus* sp.3 (Coleoptera: Curculionidae) on the leaves were highest in the summer. Fruits scraped by *Naupactus* sp.1 and sp.2 were more numerous in the spring and summer, percentage of defoliation in the autumn. *Apoptus* sp. (Coleoptera: Elateridae) on the leaves in the spring, and leaf miners (Lepidoptera) in the winter. In the case of natural enemies, *Crematogaster* sp. (Hymenoptera: Formicidae) were most abundant on the leaves and in the flowers in the winter and spring, and on the fruits in the spring when new leaves and flowers are formed. The number of *Zelus armillatus* (Hemiptera: Reduviidae), *Holopothrips* sp. (Thysanoptera: Phlaeothripidae), and the complex of spiders were greater on the leaves in the winter; and *Trybonia* sp. (Thysanoptera: Phlaeothripidae) was most abundant on the leaves in the autumn.

Key words: Pequi. *Carmenta* sp. *Naupactus* sp. *Crematogaster* sp. *Zelus armillatus*.

Resumen: Los árboles de *Caryocar brasiliense* (Caryocaraceae) tienen una amplia distribución en la sabana brasileña. Esta planta está protegida por las leyes federales y no se corta en las áreas deforestadas. Esta situación aumenta el daño a las hojas, flores y frutos por los insectos masticadores. Se estudiaron las poblaciones de herbívoros Lepidoptera, Coleoptera, Hymenoptera y sus enemigos naturales en los árboles de *Caryocar brasiliense* durante tres años consecutivos. Los insectos fitófagos fueron más abundantes a principios del invierno. La mayor riqueza y diversidad se hallaron en el verano. Los enemigos naturales fueron más abundantes en primavera e invierno, con más especies y diversidad a fines de invierno. Frutos dañados por *Carmenta* sp. (Lepidoptera: Sesiidae) y *Naupactus* sp.3 (Coleoptera: Curculionidae) en las hojas fueron más numerosos en verano. En primavera y verano las frutas atacadas por *Naupactus* sp.1 y sp.2 fueron más abundantes, el porcentaje de defoliación fue mayor en otoño. *Apoptus* sp. (Coleoptera: Elateridae) en las hojas en primavera y minadores de hoja (Lepidoptera) lo fueron más en invierno. En el caso de los enemigos naturales, *Crematogaster* sp. (Hymenoptera: Formicidae) presentó mayor abundancia en las hojas y las flores en invierno y primavera y en los frutos en primavera, cuando las nuevas hojas y flores se forman; *Zelus armillatus* (Hemiptera: Reduviidae), *Holopothrips* sp. (Thysanoptera: Phlaeothripidae), y el complejo de las arañas fueron más numerosos en las hojas en invierno, y *Trybonia* sp. (Thysanoptera: Phlaeothripidae) fue más abundante en las hojas en otoño.

Palabras clave: Pequi.*Carmenta* sp. *Naupactus* sp. *Crematogaster* sp. *Zelus armillatus*.

Introduction

About 23% of Brazil is covered with savanna or *cerrado* (Da Silva and Bates 2002). This region is characterized by high diversity of plants and insects (Bridgewater *et al.* 2004). This area is used for grain and cattle production (Aguiar and Camargo 2004), as well as reforestation (Zanuncio *et al.* 2002). *Caryocar brasiliense* Camb., 1828 (Caryocaraceae) trees have a wide distribution in the Brazilian savanna (Brandão and Gavilanes 1992; Bridgewater *et al.* 2004; Leite *et al.* 2006) and can reach over 10 meters in height and six meters in width of canopy (Leite *et al.* 2006, 2011a, b). The leaves of *C. brasiliense* are alternate, trifoliate and have high tricome density; its flowers are hermaphrodite but mostly cross are pollinated (Araújo 1995). The fruit is a drupe with 1-4 seeds, weighing 160g (fresh weigh) and with a volume of 315 cm^3 (Araújo 1995; Leite *et al.* 2006). Fruit production is annual, and *C. brasiliense* blooms between July and September, or dry period, with fructification from October to January which correspond to the rainy season (Leite *et al.* 2006). The internal mesocarp of the fruit is rich in oil, vitamins, and proteins and contains many compounds of medicinal importance. Moreover, it is also used by humans for food, production of cosmetics, lubricants, and in the pharmaceutical industry (Araújo 1995; Segall *et al.* 2005; Ferreira and Junqueira 2007; Garcia *et al.* 2007; Khouri *et al.* 2007). This plant represents the main source of income of many communities of the region (Leite *et al.* 2006).

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Coleoptera, Lepidoptera, and Hymenoptera are the most abundant orders of chewing insects in the Brazilian savanna (Pinheiro *et al.* 2002; Zanetti *et al.* 2003; Zanuncio *et al.* 2003; Leite *et al.* 2007, 2009, 2011b) and as *Caryocar brasiliense* trees are protected by federal laws are left in deforested areas which increases the damage to leaves, flowers, and fruits from chewing insects (according to communication reported by the collectors of *C. brasiliense* fruits). Insects that damage this plant are poorly known, in general, only at family level (Araújo 1995) and only a a single pest has been formally described (Freitas and Oliveira 1996; Oliveira 1997; Lopes *et al.* 2003; Boiça *et al.* 2004).

Our objective was to research the seasonality of herbivorous insects in the orders: Lepidoptera, Coleoptera, and Hymenoptera, their natural enemies, and the phenophases of *C. brasiliense* that influences them on *C. brasiliense* trees in savanna *strictu sensu* of Montes Claros in the state of Minas Gerais, Brazil.

Materials and Methods

We conducted this study in the Municipality of Montes Claros (43°55'7.3"W 16°44'55.6"S and 943 masl), in the state of Minas Gerais, Brazil, from June 2001 to June 2004 in a region with dry winter and rainy summer, which is classified as climate Aw: tropical savanna according to Köppen (Vianello and Alves 2000). The design was completely randomized with 25 replicates (25 trees) in savanna vegetation *strictu sensu* with dystrophic yellow red latosoil (sandy texture), and density of 13 *C. brasiliense* trees/ha (Leite *et al.* 2006). The savanna *sensu strictu*, a species-rich dense scrub of shrubs and trees, 8-10 m height, with a dense understory, is the more common Brazilian savanna than the grassland open forms (Ribeiro and Walter 1998; Durigan *et al.* 2002).

The distribution of Lepidoptera and Coleoptera defoliators and their natural enemies, the percentage of defoliation, the number of flowers damaged by Hymenoptera, the number of fruits scraped and bored by insects, were recorded in four fully expanded leaves, four bunches of flower, and four fruits of 25 *C. brasiliense* trees with 4.07 ± 0.18 m (average ± standard error) in height and crown width of 2.87 ± 0.13 m (Leite *et al.* 2006). This sampling was conducted in the morning by direct visual observation every month (Horowitz 1993). Defoliation was determined visually by estimating the percentage of leaf area loss on a scale from 0-100% with increments of 5% of the total areas removed (Sastawa *et al.* 2004; Mizumachi *et al.* 2006). Insects were collected with tweezers, brushes, or aspirators and preserved in vials with 70% alcohol for identification by taxonomists.

Ecological indices such as abundance of individuals, species richness, and diversity were calculated for the species identified in the samplings per tree in each season. The formula of Hill (Hill 1973) was used to calculate the diversity, and Simpson indices were used to calculate the abundance and richness of species (Townsend *et al.* 2006).

Given the lack of normality of the data Spearman's correlation was applied to data for phytophagous insects, their damage, natural enemies, flowers and fruits. Seasonal differences were tested with ANOVA with subsequent Tukey's test, using transformed data ($\sqrt{x} + 0.5$). In all tests, the significant level was 5%.

Results

Phytophagous insects were most abundant in winter and least abundant in spring and autumn (df = 72; F = 4.153; P = 0.009). There were more species and greatest diversity in the summer than in autumn (df = 72; F = 5.769; P = 0.001; df = 72; F = 6.422; P = 0.0006, respectively) (Table 1). Natural enemies were most abundant in spring and winter (df = 72; F = 5.761; P = 0.001). The fewest species were present in the autumn and the most in winter (df = 72; F = 15.127; P << 0.001). Diversity in this group was lowest in the autumn and highest in the winter (df = 72; F = 8.848; P = 0.00004) (Table 1).

The number and percentage of bored fruits by *Carmenta* sp. (Lepidoptera: Sesiidae) (df = 72; F = 15.487; P << 0.001; df = 72; F = 34.982; P = 0.00003, respectively) and the number of *Naupactus* sp.3 (Coleoptera: Curculionidae) on the leaves (df = 72; F = 5.376; P = 0.002) were greatest in the summer (Table 2). Number and percentage of scraped fruits by *Naupactus* sp.1 and sp. 2 (df = 72; F = 13.838; P << 0.001; df = 72; F = 33.892; P << 0.001, respectively) were greatest in the spring and summer, percentage of defoliation (df = 72; F = 19.489; P << 0.001) was highest in the autumn, number of *Apoptus* sp. (Coleoptera: Elateridae) on the leaves was highest in the spring (df = 72; F = 4.336; P = 0.00725), and number of leaf miners (Lepidoptera) (df = 72; F = 8.335; P << 0.001) was highest in the winter (Table 2).

In the case of natural enemies, *Crematogaster* sp. (Hymenoptera: Formicidae) had the highest abundance on the leaves (df = 72; F = 5.097; P = 0.003) and in the flowers (df

Table 1. Hill's diversity index, number of individuals and of species of natural enemies and herbivorous insects per tree of *Caryocar brasiliense.* Montes Claros, Minas Gerais State, Brazil. Autumn 2001 to Autumn 2004.

Variables	Spring	Summer	Autumn	Winter
	Natural enemies			
Diversity index	5.16 ± 0.75 b	5.00 ± 0.82 b	2.74 ± 0.50 c	6.96 ± 0.76 a
No. of individuals	13.88 ± 2.93 a	6.00 ± 1.24 b	5.88 ± 2.32 b	14.20 ± 2.31 a
No. of species	2.92 ± 0.31 b	2.52 ± 0.35 b	1.68 ± 0.28 c	3.72 ± 0.33 a
	Herbivorous			
Diversity index	2.43 ± 0.51 ab	3.26 ± 0.51 a	1.26 ± 0.18 c	1.81 ± 0.21 bc
No. of individuals	4.32 ± 1.29 b	6.2 ± 1.31 ab	4.72 ± 0.98 b	7.16 ± 0.95 a
No. of species	1.44 ± 0.24 ab	1.88 ± 0.28 a	0.84 ± 0.11 c	1.32 ± 0.17 bc

Means followed by the same letter (± standard error) in each row are not different by the test of Tukey (P < 0.05).

Table 2. Number of herbivorous insects and their damage per tree of *Caryocar brasiliense*. Montes Claros, Minas Gerais State, Brazil. Autumn 2001 to Autumn 2004.

Herbivorous data	Spring	Summer	Autumn	Winter
No. of bored fruits	0.36 ± 0.12 b	3.00 ± 0.83 a	0.00 ± 0.00 b	0.00 ± 0.00 b
No. of scraped fruits	4.00 ± 1.17 a	4.40 ± 1.30 a	0.00 ± 0.00 b	0.00 ± 0.00 b
No. of damaged flowers	0.48 ± 0.36 a	0.00 ± 0.00 a	0.00 ± 0.00 a	0.56 ± 0.27 a
% of defoliation	0.27 ± 0.06 c	0.70 ± 0.08 b	0.95 ± 0.12 a	0.72 ± 0.07 ab
% of bored fruits	3.76 ± 1.35 b	24.31 ± 3.35 a	0.00 ± 0.00 c	0.00 ± 0.00 c
% of scraped fruits	25.15 ± 2.90 a	31.94 ± 3.75 a	0.00 ± 0.00 b	0.00 ± 0.00 b
% damaged flowers	0.51 ± 0.35 a	0.00 ± 0.00 a	0.00 ± 0.00 a	2.35 ± 0.87 a
No. of *Naupactus* sp.1 (Col.: Curculionidae) on the fruits	0.04 ± 0.03 a	0.00 ± 0.00 a	0.00 ± 0.00 a	0.00 ± 0.00 a
No. of *Naupactus* sp.1 on the leaves	0.12 ± 0.11 a	0.08 ± 0.05 a	0.04 ± 0.03 a	0.04 ± 0.03 a
No. of *Naupactus* sp.2 on the fruits	0.00 ± 0.00 a	0.04 ± 0.03 a	0.00 ± 0.00 a	0.00 ± 0.00 a
No. of *Naupactus* sp.3 on the leaves	0.00 ± 0.00 b	0.64 ± 0.31 a	0.00 ± 0.00 b	0.00 ± 0.00 b
No. of *Apoptus* sp. (Col.: Elateridae) on the leaves	0.32 ± 0.11 a	0.12 ± 0.06 ab	0.00 ± 0.00 b	0.04 ± 0.03 b
No. of *Rhinochenus stigma* (Col.: Curculionidae) on the leaves	0.08 ± 0.05 a	0.00 ± 0.00 a	0.00 ± 0.00 a	0.08 ± 0.05 a
No. of *Oxyprora. flavicornis* (Orth.: Tettigoniidae) on the leaves	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.04 ± 0.03
No. of mines of Lepidoptera	3.28 ± 1.16 bc	2.16 ± 0.39 c	4.64 ± 0.98ab	6.32 ± 0.90 a
No. of *Eunica bechina* (Lep.: Nymphalidae) on the leaves	0.04 ± 0.03 a	0.08 ± 0.05 a	0.00 ± 0.00 a	0.08 ± 0.05 a
No. of Ctenuchiidae (Lep.) on the leaves	0.00 ± 0.00 a	0.00 ± 0.00 a	0.00 ± 0.00 a	0.08 ± 0.05 a
No. of Oecophoridae (Lep.) on the leaves	0.00 ± 0.00 a	0.00 ± 0.00 a	0.04 ± 0.03 a	0.04 ± 0.03 a
No. of Arctiidae (Lep.) on the leaves	0.00 ± 0.00 a	0.00 ± 0.00 a	0.00 ± 0.00 a	0.04 ± 0.03 a
No. of *Camaria* sp. (Col.: Tenebrionidae) on the leaves	0.00 ± 0.00 a	0.00 ± 0.00 a	0.00 ± 0.00 a	0.04 ± 0.03 a
No. of *Oedionychus* sp. (Col.: Alticidae) on the leaves	0.00 ± 0.00 a	0.04 ± 0.03 a	0.00 ± 0.00 a	0.00 ± 0.00 a
No. of *Diabrotica speciosa* (Col.: Chrysomelidae) on the leaves	0.04 ± 0.03 a	0.04 ± 0.03 a	0.00 ± 0.00 a	0.00 ± 0.00 a
No. of *Trigona spinipes* (Hym.: Apidae) in the flowers	0.04 ± 0.03 a	0.00 ± 0.00 a	0.00 ± 0.00 a	0.36 ± 0.35 a

Means followed by the same letter (± standard error) in each row are not different by the test of Tukey (P < 0.05).

= 72; F = 7.594; P = 0.0001) in the winter and spring, while it was on the fruits (df = 72; F = 5.697; P = 0.001) in the spring. The number of *Zelus armillatus* (Lep. and Servi, 1825) (Hemiptera: Reduviidae) (df = 72; F = 6.008; P = 0.001); *Holopothrips* sp. (Thysanoptera: Phlaeothripidae) (df = 72; F = 3.308; P = 0.02), and spiders such as *Cheiracanthium inclusum* (Hentz, 1847) (Miturgidae), *Peucetia rubrolineata* (Keyserling, 1877) (Oxyopidae), *Anelosimus* sp., *Achaearanea hirta* (Taczanowski, 1873) (Theridiidae), *Gastromicans albopilosa* (Simon, 1903), *Chira bicirculigera* (Soares and Camargo, 1948), *Rudra humilis* (Mello-Leitão, 1945), *Thiodina melanogaster* (Mello-Leitão, 1917) and *Lyssomanes pauper* (Galiano, 1945) (Salticidae), *Dictyna* sp. and sp.1 (Dictynidae); *Tmarus* sp. and sp.1 (Thomisidae), *Argiope argentata* (F, 1775), *Gasteracantha cancriformes* (L., 1758), *Argiope* sp., *Parawixia* sp. and sp.1 (Araneidae), and Anyphaenidae (df = 72; F = 6.460; P = 0.0006) were highest on the leaves in the winter; and *Trybonia intermedius* (Bagnall, 1910) and *Trybonia mendesi* (Moulton, 1933) (Thysanoptera: Phlaeothripidae) (df = 72; F = 2.853; P = 0.043) on the leaves in the autumn (Table 3).

Eunica bechina (Talbot, 1852) (Lepidoptera: Nymphalidae) (df = 72; r = 0.28; P = 0.04) and *Naupactus* sp.1+3 (r = 0.30; P = 0.03) showed a positive correlation with percentage of defoliation; *Carmenta* sp. showed a positive correlation with fruits bored (r = 1.00; P << 0.001) and *Naupactus* sp.2 with fruits scraped (r = 0.40; P = 0.007). *Trigona spinipes* (F., 1793) (Hymenoptera: Apidae) showed a positive correlation with damaged flowers (r = 0.80; P << 0.001).

The ants *Crematogaster* sp. and *Pseudomyrmex termitarius* (Smith, 1855) showed a positive correlation with flowers (r = 0.63; P = 0.0009), fruits bored by *Carmenta* sp. (r = 0.88; P = 0.0001) and those scraped by *Naupactus* sp.2 (r = 0.59; P = 0.02). The percentage of defoliation had a negative correlation with *Crematogaster* sp. (r = -0.40; P = 0.008); *P. termitarius* (r = -0.44; P = 0.004), *Holopothrips* sp. (r = -0.16; P = 0.047), *Z. armillatus* (r = -0.28; P = 0.024), spiders (r = -0.73; P = 0.003), and with the flower formation of *C. brasiliense* (r = -0.53; P = 0.0007). Lepidoptera leaf miners had a negative correlation with *Z. armillatus* (r = -0.27; P = 0.002), a barely significant relation with *P. termitarius* (r = -0.27; P = 0.05) and a significant relation with spiders (r = -0.62; P = 0.01). Lepidoptera + Coleoptera had no correlation with *P. termitarius* (r = -25; P = 0.06).

Discussion

The higher abundance of phytophagous insects and their natural enemies in the winter is probably determined by the reduction in the number of *C. brasiliense* leaves available due to their gradual loss during the dry period and by the end of this season (Leite *et al.* 2006), which results in a concentration of insects per leaf. The largest species richness and diversity of the natural enemies in the winter probably indicate

Table 3. Number of natural enemies on the leaves, flowers, and fruits per tree of *Caryocar brasiliense*. Montes Claros, Minas Gerais State, Brazil. Autumn 2001 to Autumn 2004.

Natural enemies data	Spring	Summer	Autumn	Winter
No. of *Crematogaster* sp. (Hym.: Formicidae) on the leaves	3.48 ± 1.04 a	1.32 ± 0.26 b	1.12 ± 0.28 b	3.44 ± 0.75 a
No. of *Crematogaster* sp. in the flowers	4.80 ± 1.83 a	0.00 ± 0.00 b	0.00 ± 0.00 b	3.56 ± 1.35 a
No. of *Crematogaster* sp. on the fruits	2.60 ± 1.41 a	0.76 ± 0.48 ab	0.00 ± 0.00 b	0.00 ± 0.00 b
No. of *Pseudomyrmex termitarius* (Hym.: Formicidae) on the leaves	0.24 ± 0.08 a	0.16 ± 0.07 a	0.12 ± 0.06 a	0.20 ± 0.10 a
No. of *P. termitarius* on the fruits	0.00 ± 0.00 a	0.04 ± 0.03 a	0.00 ± 0.00 a	0.00 ± 0.00 a
No. of spiders on the leaves	0.28 ± 0.09 b	0.52 ± 0.17 b	0.24 ± 0.10 b	1.28 ± 0.32 a
No. of spiders in the flowers	0.04 ± 0.03 a	0.00 ± 0.00 a	0.00 ± 0.00 a	0.08 ± 0.07 a
No. of *Zelus armillatus* (Hem.: Reduviidae) on the leaves	1.36 ± 0.68 ab	0.32 ± 0.14 b	0.28 ± 0.20 b	2.64 ± 1.18 a
No. of *Epipolops* sp. (Hem.: Geocoridae) on the leaves	0.04 ± 0.03 a	0.28 ± 0.14 a	0.32 ± 0.11 a	0.20 ± 0.08 a
No. of *Neocalvia fulgurata* (Col.: Coccinellidae) on the leaves	0.08 ± 0.05 a	0.04 ± 0.03 a	0.00 ± 0.00 a	0.48 ± 0.33 a
No. of *Chrysoperla* sp. (Neu.: Chrysopidae) the leaves	0.68 ± 0.38 a	1.32 ± 0.71 a	0.08 ± 0.05 a	0.28 ± 0.21 a
No. of *Calosoma* sp. (Col.: Carabidae) on the leaves	0.00 ± 0.00 a	0.00 ± 0.00 a	0.08 ± 0.07 a	0.00 ± 0.00 a
No. of *Holopothrips* sp. (Thy.: Phlaeothripidae) on the leaves	0.20 ± 0.10 b	0.28 ± 0.10 ab	0.08 ± 0.05 b	0.56 ± 0.16 a
No. of *Trybonia. intermedius* + *T. mendesi* (Thy.: Phlaeothripidae) on the leaves	0.08 ± 0.05 b	0.96 ± 0.32 ab	3.56 ± 2.08 a	1.48 ± 0.56 ab

Means followed by the same letter (± standard error) in each row are not different by the test of Tukey ($P < 0.05$).

that their population depends on their prey and follows those of the phytophagous insects (Oberg *et al.* 2008; Venturino *et al.* 2008). In contrast, the higher species richness and diversity of phytophagous insects in the spring/summer indicated that these insects can be limited by the quality of available food i.e. autumn. For instance, the higher abundance of flowers and fruits on *C. brasiliense* during this season (Leite *et al.* 2006) can favor an increase in the diversity of chewing insects (Peeters 2002; Coley *et al.* 2006; Kursar *et al.* 2006) reducing the dominance of one or more species i.e. greater equitability.

Caryocar brasiliense loses its leaves in August/September with new ones in September (Leite *et al.* 2006). The ants *Crematogaster* sp. and *P. termitarius* were more abundant during the formation of new leaves and flowers at end of the winter, probably due to the nectaries of leaves and flowers (Oliveira 1997; Orivel and Dejean 2002; Oliveira and Freitas 2004). In addition, these ants visited fruits bored by *Carmenta* sp. and scraped by *Naupactus* sp.2, perhaps due to the presence of sugary secretions of damaged *C. brasiliense* fruits. *Crematogaster* ants may hinder Lepidoptera and Coleoptera colonizing alive trees, except for leaf miners, as observed for larvae of *Hallonympha paucipuncta* (Spitz, 1930) (Lepidoptera: Riodinidae), an endemic butterfly of the Brazilian savanna. Spatial distribution of larvae and tending ants were strongly aggregated, suggesting an influence of ants on oviposition or larval survival (Kaminski 2008; Sendoya *et al*. 2009).

Herbivorous Lepidoptera and Coleoptera appear to be negatively affected by the presence of the ants *P. termitarius*, and other predators such as *Holopothrips* sp., *Z. armillatus* as well as spiders, reducing defoliation. Mobile predators could respond to a local increase in vegetation complexity and the presence of an alternative prey and effectively suppress herbivores (Auslander *et al.* 2003). Ants can reduce *E. bechina* infestations as well as *Edessa rufomarginata* (De Geer, 1773) (Hemiptera: Pentatomidae), *Prodiplosis floricola* (Felt, 1908) (Diptera: Cecidomyiidae) and petiole gall insects on *C. brasiliense* (Hymenoptera: Chalcidoidea) (Freitas and Oliveira 1996; Oliveira 1997).

The association between ants and extrafloral nectaries may be responsible for the reduction of damage by chewing insects on the reproductive parts of *C. brasiliense* plants as observed for *Crotalaria pallida* (Leguminosae) (Guimarães *et al.* 2006). Species of *Holopothrips* sp. scratch leaves (Cavalleri and Kaminski 2007), create galls (Cabrera and Segarra 2008), or are predators (Almeida *et al.* 2006) as are the spiders, and bugs of the genus *Zelus* spp. and those of the subfamily Asopinae (Molina-Rugama *et al*. 1998). These predators are important in different ecosystems (Landis *et al.* 2000; Almeida *et al.* 2006; Mizzel 2007; Oberg *et al.* 2008; Venturino *et al.* 2008).

The chewing insects started damaging *C. brasiliense* trees in October at the beginning of the rainy season when there were lower populations of ants. The damage by wood borers and fruit scrapers was higher in the spring and in the summer (October-March) during the period of fruit formation (Leite *et al.* 2006). The formation of flowers of *C. brasiliense* before the period of higher abundance of chewing insects may reduce the probability of damage by the latter, suggesting phenological escape mechanism of the plants by defoliators (Sloan *et al.* 2007). Higher ant visitation to extrafloral nectaries can favor the production of flowers or fruits of this plant and reduce damage to *C. brasiliense* trees by *T. spinipes*. Sprouting of leaves and flower development before the rainy period is common in perennial plants of the Brazilian savanna (Almeida *et al.* 1998; Felfini *et al.* 1999; Pedroni *et al.* 2002; Almeida *et al.* 2006; Leite *et al.* 2006). This allows plants to increase photosynthetic area when the efficiency of predation by insects is lower. In addition, there is no heavy rain during this period, and the low quantity of leaves facilitates the ability of pollinators to find *C. brasiliense* flowers such as observed for Felfini *et al.* (1999) with *Stryphnodendron adstringens* (Mart.) Coville (Fabaceae).

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