SEASONAL ABUNDANCE OF HEMIPTERANS ON *CARYOCAR BRASILIENSE* (MALPIGHIALES: CARYOCARACEAE) TREES IN THE CERRADO

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Abstract

Caryocar brasiliense Camb. (Malpighiales: Caryocaraceae) trees have a wide distribution in the cerrado. This plant is protected by federal laws and is untouched in deforested areas of the cerrado. Under these circumstances, the damage to leaves, flowers, and fruits from sucking hemipterans has increased. We studied populations of sucking insects and their predators on *C. brasiliense* trees in the cerrado during each season for 3 successive years. The numbers of sucking insect individuals on *C. brasiliense* trees were similar among the seasons of the year. However, the highest number of species and greatest diversity occurred in winter. Predators were most abundant in spring and winter, with highest diversity and number of species in winter. We observed 7 rare, 2 common, and 1 constant species of sucking insects; and 4 rare, 8 common, and 1 constant species of predators on *C. brasiliense* trees. The greatest numbers of various sucking insect species were observed by seasons as follows: *Aconophora* sp. (Membracidae) on fruits and *Frequenamia* sp. (Cicadellidae) on leaves in the winter; *Aphis gossypii* (Glover) (Aphididae) and *Mahanarva* sp. (Cercopidae) in the spring; and *Dikrella* sp. (Hemiptera: Cicadellidae) on the leaves in the summer and autumn. For predators, *Crematogaster* sp. (Hymenoptera: Formicidae) had the lowest abundance on the leaves in the summer, and highest abundance in the flowers in the winter and spring, while in spring it was most abundant on the fruits, and in the autumn *Trybonia* sp. (Thysanoptera: Phlaeothripidae) on the leaves was the most abundant. Higher number of ants *Crematogaster* sp. was observed in *Caryocar brasiliense* trees that presented large numbers of *Dikrella* sp.. Higher numbers of predators *Trybonia* sp., *Chrysoperla* sp. (Neuroptera: Chrysopidae), and total of predator thrips were associated with decreasing numbers of *Dikrella* sp., *A. gossypii*, and total of sucking insects respectively. The increase in the numbers of individuals and species of predators were correlated with the reduction of these same ecological parameters of the sucking insects. We argue that this differential temporal distribution of sucking insects and their predators was influenced for phenology of plant and weather.

Key Words: leafhoppers, seasons, predators, pequi

Resumen

Los árboles de *Caryocar brasiliense* Camb. (Malpighiales: Caryocaraceae) tienen una amplia distribución en lo cerrado. Esta planta está protegida por las leyes federales y se deja en las áreas deforestadas de lo cerrado. Esta situación aumenta el daño a las hojas, flores y frutos de los insectos chupadores (Hemiptera). Se estudiaron las poblaciones de insectos chupadores y sus depredadores en árboles de *C. brasiliense* durante tres años consecutivos durante cada temporada en el cerrado. Número de ejemplares de insectos chupadores de árboles de *C. brasiliense* fue similar entre las estaciones del año. Sin embargo, había más especies y mayor diversidad en el invierno. Los depredadores fueron más abundantes en primavera e invierno, con mayor diversidad y número de especies durante el invierno. Hemos observado 7 raras, 2 comunes, y 1 especie constante de los insectos chupadores, y 4 raras, 8 comunes y 1 especie constante de los depredadores en árboles de *C. brasiliense.* El número de insectos chupadores *Aconophora* sp. (Membracidae) en frutas y *Frequenamia* sp. (Cicadellidae) en las hojas fue mayor en el invierno; *Aphis gossypii* (Glover) (Aphididae) y *Mahanarva* sp. (Cercopidae) en la primavera, y Dikrella sp. (Hemiptera: Cicadellidae) en verano y otoño en las hojas. Para los depredadores, *Crematogaster* sp. (Hymenoptera: Formicidae) tuvo la menor abundancia en las hojas en el verano, y la mayor abundancia en las flores en el invierno y la primavera, mientras estaba en los frutos en la primavera, y *Trybonia* sp. (Thysanoptera: Phlaeothripidae) en las hojas en otoño. Mayor número de hormigas *Crematogaster* sp. se observó en árboles del *C. brasiliense* que presentan un gran número de *Dikrella* sp.. Los números más altos de los depredadores *Trybonia* sp., *Chrysoperla* sp. (Neuroptera: Chrysopidae), y el total de los trips depredadores se asociaron con disminución del número de *Dikrella* sp, *A. gossypii*, y total de los insectos chupadores, respectivamente. El aumento en el número de individuos y especies de depredadores se correlaciona con la disminución de estos mismos parámetros ecológicos de los insectos chupadores. Nosotros sostenemos que esta distribución diferencial temporal de los insectos chupadores y sus depredadores fue influenciado por la fenología de la planta y el clima.

Palabras Clave: chicharritas, las estaciones, los depredadores, pequi

The Cerrado occupies about 23% of the Brazilian territory (Da Silva & Bates 2002) and is characterized by high diversity of plants and insects and represents a high degree of endemism (Bridgewater et al. 2004). Due to increasing threats to its biodiversity, the Cerrado has been selected as a biodiversity hotspot (Myers et al. 2000). The primary use of the Cerrado is for grain and cattle production (Aguiar & Camargo 2004). In addition, reforestation with exotic species, primarily *Eucalyptus* (Zanuncio et al. 2002) is underway. Through several governmental mechanisms and incentives the cerrado has been devastated in the last 5 decades leaving only 20% of the land intact (Klink & Machado 2005). Naturally, the cerrado is formed by a complex mosaic of phytophysiographies that range from open cerrado formations (*campo limpo*) up to tall and woody forests of 10-15 meters high, called *Cerradão* (Oliveira & Marquis 2002). In southeastern Brazil, large patches of this rich cerrado are seen immersed in a matrix of agriculture (primarily soybean and sugar cane), cattle farms and cities (urbanization). This is the case in Montes Claros in northern Minas Gerais state.

Caryocar brasiliense Camb. (Malpighiales: Caryocaraceae), a flagship species of the Cerrado for fomenting support for conservation, is widely distributed (Brandão & Gavilanes 1992; Bridgewater et al. 2004; Leite et al. 2006a) and can reach up to 10 meters high while the canopy may reach 6 meters wide (Leite et al. 2006a, 2011a, 2012a). The leaves of *C. brasiliense* are alternate, trifoliate and have high trichome density; the flowers are hermaphrodite but mostly cross pollinated. Fruit production is annual, and *C. brasiliense* blooms between Jul and Sep (dry period) and bears fruit from Oct into Jan (rainy season) (Leite et al. 2006a). The fruit is a drupe with 1-4 seeds, weighing 158.49 ± 8.14 g (fresh weigh) and with a volume of 314.90 ± 20.93 cm^3 (Leite et al. 2006a). Its fruit has an internal mesocarp rich in oil, vitamins, and proteins, and contain many compounds of medicinal importance. Not surprisingly, pequi is widely used by humans for food, production of cosmetics, lubricants, and in the pharmaceutical industry (Segall et al. 2005; Ferreira & Junqueira 2007; Garcia et al. 2007; Khouri et al. 2007). This species represents the main source of income of many communities (Leite et al. 2006a). *Caryocar brasiliense* trees are protected by federal laws, and hence are left in deforested areas of the Cerrado**.** Fruit collectors have asserted that the leaves, flowers and fruits of isolated trees suffer high damage inflicted by sucking insects (Hemiptera) (personal communication from collectors of *C. brasiliense* fruits). On the other hand, the insects that damage *C. brasiliense* are poorly known and, in general, with only 1 species (Freitas & Oliveira 1996; Oliveira 1997; Lopes et al. 2003; Boiça et al. 2004; Leite et al. 2009, 2011a,b,c,d,e, 2012a,b,c). Insect pests of *C. brasiliense* number about 10 and include *Eunica bechina* (Talbot, 1852) (Lepidoptera: Nymphalidae), *Edessa rufomarginata* (De Geer, 1773) (Hemiptera: Pentatomidae), *Prodiplosis floricola* (Felt, 1908) (Diptera: Cecidomyiidae), *Carmenta* sp. (Lepidoptera: Sesiidae), *Trigona spinipes* (Fabr.) (Hymenoptera: Apidae), *Eurytoma* sp. (Hymenoptera, Eurytomidae), *Bruchophagus* sp. (Hymenoptera: Eurytomidae), and species belonging to Eulophidae (Hymenoptera), and Cossidae (Lepidoptera). The damages to *C. brasiliense* caused by these species individually or jointly are poor known and, in general, previous studies have focused on individual pest species without regard to others (Freitas & Oliveira 1996; Oliveira 1997, Lopes et al. 2003; Boiça et al. 2004; Leite et al. 2009, 2011a,b,c,d,e, 2012a,b,c). However, in the present study as many pest species as possible were included.

In order to better manage and protect the remaining *C. brasiliense* in the wild and on plantations, it is necessary to understand the ecology of the insects that interact with this economically valuable tree.

Our objective was to research the seasonality of sucking insects (Hemiptera) and their arthropod predators, and the phenophases of *C. brasiliense* that influences these arthropods on this tree, in strict sense Cerrado (a species-rich dense scrub of shrubs and trees, 8-10 m high and a dense understory) at Montes Claros in the state of Minas Gerais, Brazil.

Material and Methods

Study sites

The study was done in the municipality of Montes Claros (S 16° 44' 55.6" W 43° 55' 7.3" at 943 m asl), in the state of Minas Gerais, Brazil, during 3 consecutive yr (Jun 2008 through Jun 2011). The region has dry winters and rainy summers, and its climate is classified as climate Aw: tropical savanna, according to the Köppen System (Vianello & Alves 2000). The climatic data (temperature, rainfall, relative humidity, sunlight, wind directions and intensities) were obtained from "Estação Climatológica Principal de Montes Claros do 5º DISME – INMET". The area was a strict sense Cerrado (a species-rich dense scrub of shrubs and trees, 8-10 m high and a dense understory) with a dystrophic yellow red oxisol with sandy texture, and density of 13 *C. brasiliense* trees/ha (Leite et al. 2006a, 2011b).

The strict sense Cerrado is more typical of the Cerrado than grassland open forms (Ribeiro & Walter 1998; Durigan et al. 2002). Adult trees *C. brasiliense* in the area were 4.07 ± 0.18 m (average ± SE) high with a crown width of 2.87 ± 0.13 m (Leite et al. 2006a).

Study design

The design was completely randomized with 25 replicates (1 tree/replicate) in Cerrado vegetation. Each month we walked ~600 m in a straight line, and every 50 m we collected data on the *C. brasiliense* tree. Adult trees of *C. brasiliense* (producing fruits) were randomly sampled in each collection. Despite the 25 replications, we collected data during 3 consecutive years in order to capture as many species of insects as possible (i.e., rare species), which might not be possible in a single year.

The distribution of sucking insects and their predators were recorded in 4 fully expanded leaves; 4 bunches of flowers; and 4 fruits of each of *C. brasiliense* trees. Sampling was conducted in the morning (7-11 a.m.) by direct visual observation every mo (Horowitz 1993). Insects were collected with tweezers, brushes, or aspirators and preserved in vials with 70% alcohol for identification by taxonomists. A total of 3,600 leaves, 900 flowers (Jul-Sep), and 1,500 fruits (Sep-Jan) of *C. brasiliense* were evaluated during the 3 yr.

The abundances of individual sucking insects and individual predators, species richness, and diversities were calculated per tree in each season. Hill's formula (Hill 1973) was used to calculate diversity, and Simpson index was used to calculate the abundances and richness of species (Townsend et al. 2006; Lazo et al. 2007). We calculated the percentage of samples that contained each species. Presence of a species was by the number 1, and its absence by number 0. The frequencies of each species of sucking insects and predatory arthropods in the samples were classified as: a) constant (presence ≥ 50%), b) common (10% < presence ≤ 49%), and c) rare (presence ≤ 10%) (adapted by Siqueira et al. 2008).

Statistical analyses

Correlations of diversity indices, numbers of individuals and species of sucking insects with diversity indices, numbers of individuals and species of predators were subjected to analysis of variance (ANOVA) ($P < 0.05$) and simple regression analysis ($P < 0.05$). We made the same analysis with each species of predators, with each sucking insect species, as well as climatic data and sucking insects and their predators. The effects of the seasons of the yr on the ecological indices, and on the numbers of individuals of each species of sucking insects and their predators (transformed to $\sqrt{x + 0.5}$) were tested with ANOVA ($P < 0.05$) and subsequently with Tukey's test ($P < 0.05$).

Results

We observed 7 rare, 2 common, and 1 constant species of sucking insects; and 4 rare, 8 common, and 1 constant species of predatory arthropods on *C. brasiliense* trees (Table 1). The numbers of individuals of sucking insects were similar ($P > 0.05$) among the seasons of the year. However, there were more species and greatest diversity in the winter. Predators were most abundant in spring and winter, with highest diversity and number of species in winter (Tables 2 and 3).

With respect to sucking insects (Table 4), the numbers of *Aconophora* sp. (Membracidae) on fruits and *Frequenamia* sp. (Cicadellidae) on leaves were greatest in the winter; also greatest on the leaves in the spring were *Aphis gossypii* (Glover) (Aphididae) and *Mahanarva* sp. (Cercopidae). On the other hand *Dikrella* sp. (Hemiptera: Cicadellidae) were most abundant on the leaves in summer and autumn. With respect to predators (Table 5), *Crematogaster* sp. (Hymenoptera: Formicidae), had the lowest abundance on the leaves in the summer, and highest abundance in the flowers in the winter and spring, while it was prevalent on the fruits in the spring; *Trybonia intermedius* (Bagnall, 1910) and *Trybonia mendesi* (Moulton, 1933) (Thysanoptera: Phlaeothripidae) were most prevalent on the leaves in the autumn.

Higher numbers of ants *Crematogaster* sp. were observed in *Caryocar brasiliense* trees that had large numbers of *Dikrella* sp. (Hemiptera: Cicadellidae). Higher numbers of predators *Trybonia* sp. (Thysanoptera: Phlaeothripidae), *Chrysoperla* sp. (Neuroptera: Chrysopidae), and total of predator thrips were associated with decreasing numbers of *Dikrella* sp., *A. gossypii*, and total of sucking insects, respectively. The increase in the numbers of individuals and species of predators were correlated with the reduction of these same ecological parameters of the sucking insects (Fig. 1).

The highest temperatures and rainfall amounts were observed in spring, the highest RH in the summer, and longest daily h of sunlight in autumn and winter, but the lowest wind velocities were recorded in autumn (Table 6). Temperatures correlated negatively with the Hill's index of a number of predators, the number of species of

TABLE 1. ORDERS AND FAMILIES OF SPECIES OBSERVED ON *CARYOCAR BRASILIENSE* TREES, THE OBJECTS ON WHICH THEY FED AND THE FREQUENCIES OF THEIR OCCURRENCES DURING THE DAY AT MONTES CLAROS, MINAS GERAIS STATE, BRAZIL DURING AUTUMN 2008 TO AUTUMN 2011.

Order	Family	Species	Feeding	Occurrence
Coleoptera	Carabidae	*Calosoma* sp.	Predator	Rare-L
	Coccinelidae	*Neocalvia fulgurata* Mulsant	Predator	Rare-L
Hemiptera	Aethalionidae	*Aethalium reticulatum* L.	Leaves	Rare-L
			Flowers	Rare-Fl
	Aleyrodidae	*Bemisia tabaci* (Genn.)	Leaves	Rare-L
	Aphididae	*Aphis gossypii* (Glover)	Leaves	Rare-L
	Cercopidae	*Mahanarva* sp.	Leaves	Rare-L
	Cicadellidae	*Dikrella* sp.	Leaves	Constant-L
		Frequenamia sp.	Leaves	Rare-L
	Geocoridae	*Epipolops* sp.	Predator	Common-L
	Membracidae	*Aconophora* sp.	Leaves	Rare-L
			Flowers	Rare-Fl
			Fruits	Rare-Fr
		NI*	Leaves	Rare-L
	Pentatomidae	*Edessa rufomarginata* De Geer	Leaves	Rare-L
	Pseudococcidae	*Pseudococcus* sp.	Leaves	Common-L
	Reduviidae	*Zelus armillatus* (Lep. and Servi)	Predator	Common-L
Hymenoptera	Formicidae	*Camponotus novograndensis* Mayr	Generalist	Common-L
		Cephalotes minutus (Fabr.)	Generalist	Rare-L
		Crematogaster sp.	Generalist	Constant-L
			Generalist	Common-Fl
			Generalist	Common-Fr
		Dorymyrmex sp.	Generalist	Rare-L
		Pseudomyrmex termitarius Smith	Predator	Common-L
			Predator	Rare-Fr
Neuroptera	Chrysopidae	*Chrysoperla* sp.	Predator	Common-L
Thysanoptera	Phlaeothripidae	*Holopothrips* sp.	Predator	Common-L
		Trybonia intermedius Bagnall	Predator	Common-L
		Trybonia mendesi Moulton	Predator	Common-L
Araneae	**	Spiders	Predator	Common-L
			Predator	Rare-Fl

*NI = none identified. ** spiders = *Cheiracanthium inclusum* Hentz (Miturgidae); *Peucetia rubrolineata* (Keyserling) (Oxyopidae); *Anelosimus* sp., *Achaearanea hirta* (Taczanowski) (Theridiidae); *Gastromicans albopilosa* Simon, *Chira bicirculigera* Soares and Camargo, *Rudra humilis* Mello-Leitão, *Thiodina melanogaster* Mello-Leitão and *Lyssomanes pauper* Galiano (Salticidae); *Dictyna* sp. and sp.1 (Dictynidae); *Tmarus* sp. and sp.1 (Thomisidae); *Argiope argentata* (Fabr.), *Gasteracantha cancriformes*, *Argiope* sp., *Parawixia* sp. and sp.1 (Araneidae); and Anyphaenidae. L = leaves, Fl = flowers, and Fr = fruits. *Caryocar brasiliense* blooms between Jul and Sep (dry period) and bears fruit from Oct into Jan (rainy season).

TABLE 2. HILL'S DIVERSITY INDEX VALUES, NUMBERS OF INDIVIDUALS SPECIES OF ARTHROPOD PREDATORS, AND SUCKING INSECTS (HEMIPTERA) PER *CARYOCAR BRASILIENSE* TREE AT MONTES CLAROS, MINAS GERAIS STATE, BRAZIL DURING AUTUMN 2008 TO AUTUMN 2011.

Variables	Summer	Autumn	Winter	Spring
	Predators			
Diversity index**	3.71 ± 0.71 AB	4.80 ± 0.71 AB	5.21 ± 0.61 A	3.05 ± 0.40 B
No. of individuals**	5.20 ± 1.19 B	10.16 ± 2.23 AB	12.16 ± 1.83 A	12.88 ± 2.92 A
No. of species*	2.08 ± 0.36 B	2.72 ± 0.30 AB	3.12 ± 0.21 A	2.12 ± 0.20 B
	Sucking insects (Hemiptera)			
Diversity index*	1.16 ± 0.17 B	2.00 ± 0.22 AB	2.38 ± 0.26 A	2.02 ± 0.32 AB
No. of individuals n.s.	11.12 ± 2.87	12.24 ± 2.05	13.08 ± 2.51	11.88 ± 4.08
No. of species*	0.84 ± 0.12 B	1.32 ± 0.12 AB	1.68 ± 0.17 A	1.32 ± 0.16 AB

Means within a row followed by the same letter (average ± SE) are not different by the test of Tukey (* = $P < 0.01$ and ** = $P < 0.05$). n.s. = not significant by ANOVA ($P > 0.05$).

TABLE 3. ANOVA ANALYSIS OF THE EFFECT OF THE SEASONS ON THE ECOLOGICAL INDICES AND ABUNDANCES OF SUCKING INSECTS (HEMIPTERA) AND ARTHROPOD PREDATORS AT MONTES CLAROS, MINAS GERAIS STATE, BRAZIL DURING AUTUMN 2008 TO AUTUMN 2011.

Variables	ANOVA		Variables	ANOVA	
Predators	*F*	*P*	Predators	*F*	*P*
Diversity index	2.746	0.04913	*Holopothrips* sp.-L n.s.	1.899	0.13737
No. of individuals	4.005	0.01075	*Trybonia* sp.-L	4.696	0.00473
No. of species	5.260	0.00245	Sucking insects	*F*	*P*
Crematogaster sp.-L	6.543	0.00056	Diversity index	3.787	0.01396
Crematogaster sp.-Fl	7.594	0.00017	No. of individuals n.s.	0.076	0.64213
Crematogaster sp.-Fr	5.697	0.00148	No. of species	5.051	0.00312
Crematogaster sp.	8.760	0.00005	*A. reticulatum* -L n.s.	1.000	0.39215
P. termitarius-L n.s.	1.225	0.30682	*A. reticulatum*-Fl n.s.	1.000	0.39215
P. termitarius-Fr n.s.	1.000	0.39215	*A. reticulatum* n.s.	1.500	0.22185
P. termitarius n.s.	1.037	0.38164	*Aconophora* sp.-L n.s.	1.584	0.20067
C. novograndensis -Ln.s.	1.000	0.39215	*Aconophora* sp.-Fl n.s.	1.862	0.14368
Cephalotes minutus-Ln.s.	2.087	0.10946	*Aconophora* sp.-Fr	4.616	0.00520
Dorymyrmex sp.-L n.s.	2.087	0.10946	*Aconophora* sp.	5.192	0.00265
Spiders-L n.s.	2.659	0.05465	*Frequenamia* sp.-L	3.273	0.02594
Spiders-Fl n.s.	0.725	0.45321	*Edessa rufomarginata*-Ln.s.	0.852	0.41892
Spiders	3.080	0.03278	Membracidae-L n.s.	1.000	0.39215
Zelus armillatus-L n.s.	1.525	0.21545	*Dikrella* sp.-L	10.831	0.00000
Epipolops sp.-L n.s.	1.286	0.28561	*Pseudococcus* sp.-L n.s.	1.577	0.20234
Neocalvia fulgurata-Ln.s.	1.079	0.36357	*Aphis gossypii*-L	6.039	0.00100
Chrysoperla sp.-L n.s.	0.807	0.42781	*Bemisia tabaci*-L n.s.	0.224	0.51052
Calosoma sp.-L n.s.	1.000	0.39215	*Mahanarva* sp.-L	3.224	0.02752

L = leaves, Fl = flowers, and Fr = fruits. Values of *F* and *P* were obtained by ANOVA. *df's* of treatments, blocks, and errors were 3, 24, and 72, respectively. n.s. = not significant by ANOVA ($P > 0.05$). *Caryocar brasiliense* blooms between Jul and Sep (dry period) and bears fruit from Oct into Jan (rainy season).

TABLE 4. NUMBERS OF SUCKING INSECTS (HEMPITERA)) ON LEAVES, FLOWERS AND FRUITS PER TREE OF *CARYOCAR BRASILIENSE* AT MONTES CLAROS, MINAS GERAIS STATE, BRAZIL DURING AUTUMN 2008 TO AUTUMN 2011.

Sucking insects	Summer	Autumn	Winter	Spring
Aethalium reticulatum-L n.s.	0.00 ± 0.00	0.00 ± 0.00	0.04 ± 0.03	0.00 ± 0.00
Aethalium reticulatum-Fl n.s.	0.00 ± 0.00	0.00 ± 0.00	0.16 ± 0.15	0.00 ± 0.00
Total *A. reticulatum* n.s.	0.00 ± 0.00	0.00 ± 0.00	0.20 ± 0.16	0.00 ± 0.00
Aconophora sp.-L n.s.	0.00 ± 0.00	0.48 ± 0.31	0.08 ± 0.07	0.12 ± 0.06
Aconophora sp.-Fl n.s.	0.00 ± 0.00	0.00 ± 0.00	0.72 ± 0.52	0.00 ± 0.00
Aconophora sp.-Fr**	0.00 ± 0.00 B	0.00 ± 0.00 B	4.68 ± 2.37 A	0.28 ± 0.28 B
Total *Aconophora* sp.**	0.00 ± 0.00 B	0.48 ± 0.31 B	5.48 ± 2.48A	0.40 ± 0.28 B
Frequenamia sp.-L**	0.00 ± 0.00 B	0.00 ± 0.00 B	0.12 ± 0.06 A	0.00 ± 0.00 B
Edessa rufomarginata-L n.s.	0.00 ± 0.00	0.32 ± 0.28	0.08 ± 0.07	0.08 ± 0.05
Membracidae-L n.s.	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.04 ± 0.03
Dikrella sp.-L*	10.96 ± 2.85 A	10.60 ± 2.13 A	6.00 ± 1.32 AB	3.24 ± 0.94 B
Pseudococcus sp.-L n.s.	0.04 ± 0.03	0.76 ± 0.49	1.04 ± 0.66	0.04 ± 0.03
Aphis gossypii-L*	0.04 ± 0.03 B	0.00 ± 0.00 B	0.12 ± 0.08 B	7.76 ± 4.24 A
Bemisia tabaci-L n.s.	0.04 ± 0.03	0.08 ± 0.05	0.04 ± 0.03	0.04 ± 0.03
Mahanarva sp.-L**	0.04 ± 0.03 B	0.00 ± 0.00 B	0.00 ± 0.00 B	0.28 ± 0.14 A

Means within a row followed by the same letter (average ± SE) are not different by the test of Tukey (* = $P < 0.01$ and ** = $P < 0.05$). n.s. = not significant by ANOVA ($P > 0.05$). L = leaves, Fl = flowers, and Fr = fruits. *Caryocar brasiliense* blooms between Jul and Sep (dry period) and bears fruit from Oct into Jan (rainy season).

Table 5. Numbers of arthropod predators on leaves, flowers and fruits per tree of Caryocar brasiliense at Montes Claros, Minas Gerais state, Brazil during autumn 2008 to autumn 2011.

Predators	Summer	Autumn	Winter	Spring
Crematogaster sp.-L**	0.72 ± 0.19 B	2.68 ± 0.47 A	3.24 ± 0.70 A	2.72 ± 0.87 A
Crematogaster sp.-Fl**	0.00 ± 0.00 B	0.00 ± 0.00 B	3.56 ± 1.35 A	4.80 ± 1.83 A
Crematogaster sp.-Fr*	0.76 ± 0.48A B	0.00 ± 0.00 B	0.00 ± 0.00 B	2.60 ± 1.41 A
Total *Crematogaster* sp.**	1.48 ± 0.53 B	2.68 ± 0.47 B	6.80 ± 1.69 A	10.12 ± 2.99 A
P. termitarius-L n.s.	0.12 ± 0.06	0.08 ± 0.05	0.28 ± 0.10	0.24 ± 0.08
P. termitarius-Fr n.s.	0.04 ± 0.03	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Total *P. termitarius* n.s..	0.16 ± 0.07	0.08 ± 0.05	0.28 ± 0.10	0.24 ± 0.08
C. novograndensis -L n.s.	0.04 ± 0.03	0.04 ± 0.03	0.16 ± 0.07	0.04 ± 0.03
Cephalotes minutus-L n.s.	0.00 ± 0.00	0.00 ± 0.00	0.08 ± 0.05	0.00 ± 0.00
Dorymyrmex sp. n.s.	0.00 ± 0.00	0.00 ± 0.00	0.08 ± 0.05	0.00 ± 0.00
Spiders-L n.s.	0.44 ± 0.13	0.68 ± 0.17	0.84 ± 0.21	0.36 ± 0.11
Spiders-Fl n.s.	0.00 ± 0.00	0.00 ± 0.00	0.08 ± 0.07	0.04 ± 0.03
Total spiders n.s.	0.44 ± 0.13	0.68 ± 0.17	0.92 ± 0.21	0.40 ± 0.11
Zelus armillatus-L n.s.	0.32 ± 0.14	1.44 ± 0.97	2. 12 ± 1.05	0.72 ± 0.30
Epipolops sp.-L n.s.	0.28 ± 0.16	0.36 ± 0.12	0.08 ± 0.05	0.12 ± 0.08
Neocalvia fulgurate-L n.s.	0.00 ± 0.00	0.28 ± 0.28	0.28 ± 0.13	0.04 ± 0.03
Chrysoperla sp.-L n.s.	0.80 ± 0.55	0.28 ± 0.24	0.28 ± 0.21	1.00 ± 0.61
Calosoma sp.-L n.s.	0.00 ± 0.00	0.08 ± 0.07	0.00 ± 0.00	0.00 ± 0.00
Holopothrips sp.-L n.s.	0.24 ± 0.10	0.40 ± 0.12	0.40 ± 0.12	0.08 ± 0.07
Trybonia sp.-L **	1.44 ± 0.52 AB	3.84 ± 1.85 A	0.68 ± 0.41 B	0.12 ± 0.08 B

Means within a row followed by the same letter (average ± SE) are not different by the test of Tukey (* = P < 0.01 and ** = P < 0.05). n.s. = not significant by ANOV A (P > 0.05). L = leaves, Fl = flowers, and Fr = fruits. *Caryocar brasiliense* blooms between Jul and Sep (dry period) and bears fruit from Oct into Jan (rainy season).

Table 6. temperature (°C), rainfall (mm), relative humidity of air (%), sunlight (h), and velocity of wind (m/sec) at Montes Claros, Minas Gerais state, Brazil during autumn 2008 to autumn 2011.

Variables	Sunnner	Autumn	Winter	Spring
Temperature* *	24.10 ± 0.11 B	22.16 ± 0.30 C	22.78 ± 0.23 C	25.05 ± 0.27 A
Rainfa1l**	5.15 ± 0.73 B	1.04 ± 0.35 B	1.03 ± 0.40 B	22.48 ± 7.59 A
Humidity*	75.80 ± 1.21 A	64.31 ± 1.51 B	52.36 ± 0.98 C	63.97 ± 2.80 B
Sunlight **	5.98 ± 0.32 B	8.33 ± 0.16 A	8.06 ± 0.20 A	6.84 ± 0.56 B
Wind**	2048 ± 0.29 A	1.80 ± 0.02 B	2.30 ± 0.06 A	2.12 ± 0.03 AB
		ANOVA		
	F	*P*	df	
Temperature	25.709	0.00000	72	
Rainfall	7.176	0.00028	72	
Humidity	33.807	0.00000	72	
Sunlight	11.085	0.00000	72	
Wind	3.498	0.01976	72	

Means within a row followed by the same letter (average ± SE) are not different by the test of Tukey (* = $P < 0.01$ and ** = $P < 0.05$).

sucking insects, the numbers of *Trybonia* sp. Thysanoptera per tree, and the number of *Aconophora* sp. (Membracidae) on the fruits per tree. On the other hand, increased of temperature correlated with increased numbers of *Crematogaster* sp. in flowers per tree and the numbers of *Chrysoperla* sp. on the leaves per tree (Fig. 2). Sunlight correlated negatively with the number of *Crematogaster* sp. on fruits per tree and *Mahanarva* sp. on the leaves per tree; rainfall correlated positively with the number of *Crematogaster* sp. on the flowers per tree and RH correlated negatively with the number of *Zelus armillatus* (Lep. and Servi) (Reduviidae) on the leaves per tree (Fig. 3).

Discussion

The greater species richness and diversity of sucking insects in the winter is probably determined by the reduction in the number of *C.*

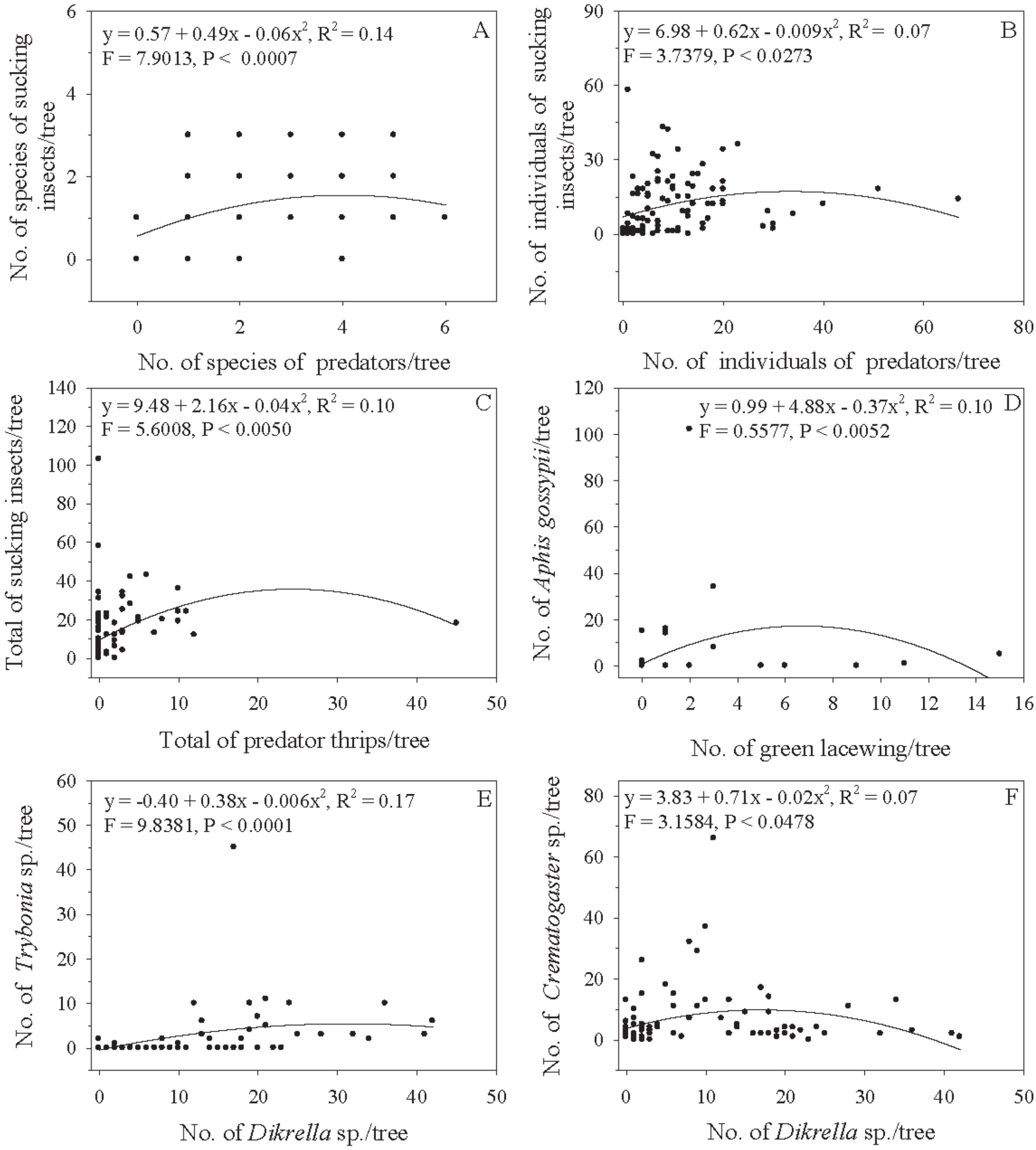

Fig. 1. Relationships between numbers of species and individuals of arthropods predaceous and numbers of species and individuals of sucking insects, respectively; numbers of total predator thrips and numbers of total sucking insects; numbers of green lacewing and numbers of *Aphis gossypii*; numbers of *Dikrella* sp. and numbers of *Trybonia* sp. and *Crematogaster* sp., respectively, on *Caryocar brasiliense* trees in Montes Claros, Minas Gerais State, Brazil. Samples = 100.

brasiliense leaves available due to their gradual loss during the dry period and by the end of this season (Leite et al. 2006a), which results in a concentration of herbivore insects per leaf. The greatest species richness, abundance and diversity of the predators, which was observed in the winter, probably indicates that their populations depend on their prey and follow those of the sucking insects (Oberg et al. 2008; Venturino et al. 2008).

Caryocar brasiliense loses its leaves in Aug/Sep with new ones developing in Sep, a period without rainfall, strong winds and much sunlight (Leite et al. 2006a). In Sep we observed higher numbers of *Frequenamia* sp. cicadellids. *Crematogaster* sp. ants were also more abundant during

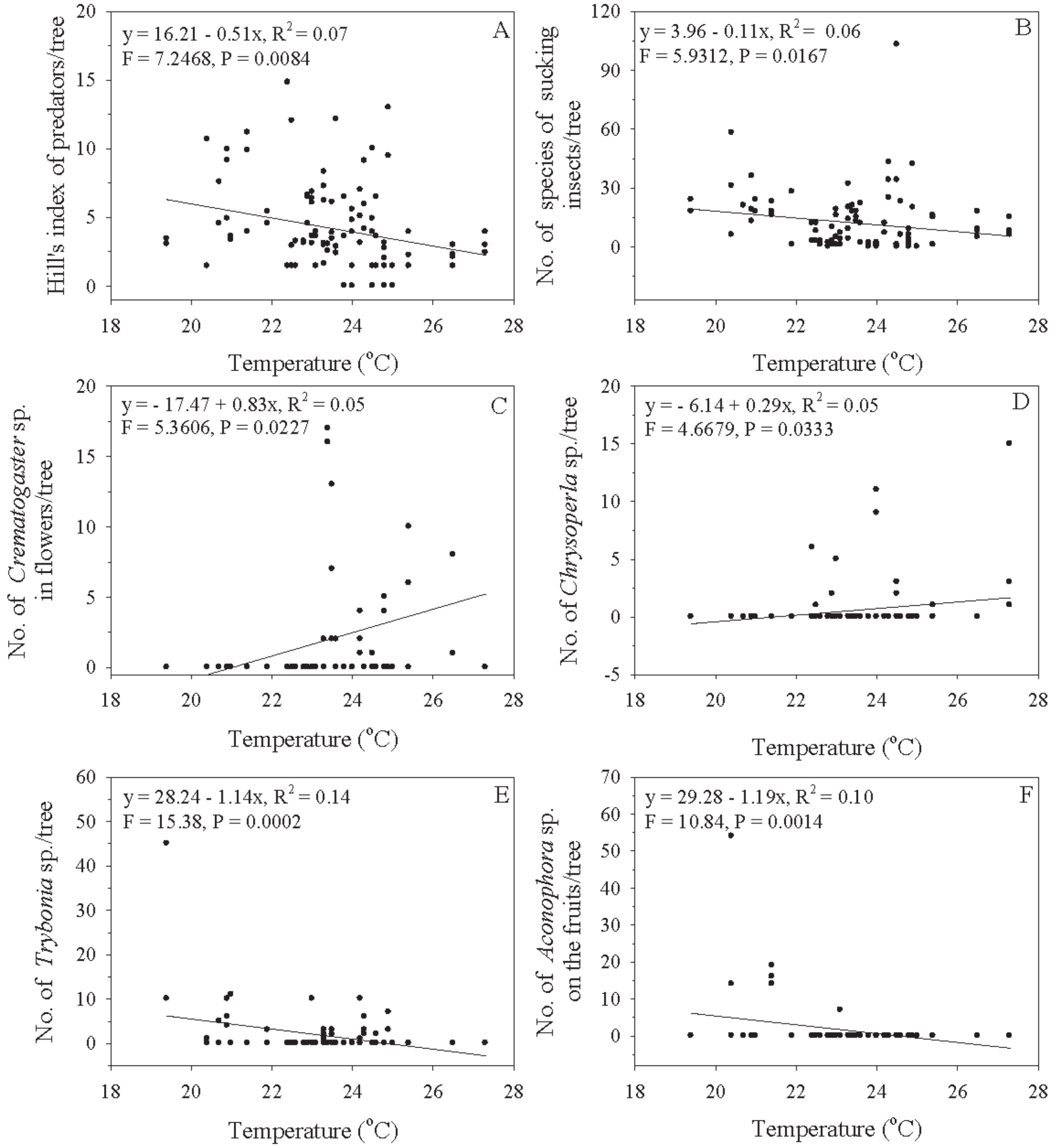

Fig. 2. Relationships between temperature and Hill's index of arthropods predaceous, numbers of species of sucking insects, numbers of *Crematogaster* sp., numbers of *Chrysoperla* sp., numbers of *Trybonia* sp., and numbers of *Aconophora* sp., respectively, on *Caryocar brasiliense* trees in Montes Claros, Minas Gerais State, Brazil. Samples = 100.

the formation of new leaves and flowers at end of the winter probably due to the nectaries of the leaves and the flowers (Oliveira 1997; Orivel & Dejean 2002; Oliveira & Freitas 2004). *Caryocar brasiliense* begins to produces of fruit at the end of Sep. and start of Oct (Leite et al. 2006a), when *Aconophora* sp. membracids were very abundant. In addition, *Crematogaster* sp. visited fruits infested with Coleoptera and Lepidoptera borer species, perhaps because of the presence of sugary exudates of damaged *C. brasiliense* fruits (Leite et al. 2012b,c).

Ants can reduce *E. bechina* infestations as well as *E. rufomarginata*, *P. floricola* and petiole gall insects (Hymenoptera: Chalcidoidea) on *C. brasiliense* (Freitas & Oliveira 1996; Oliveira 1997).

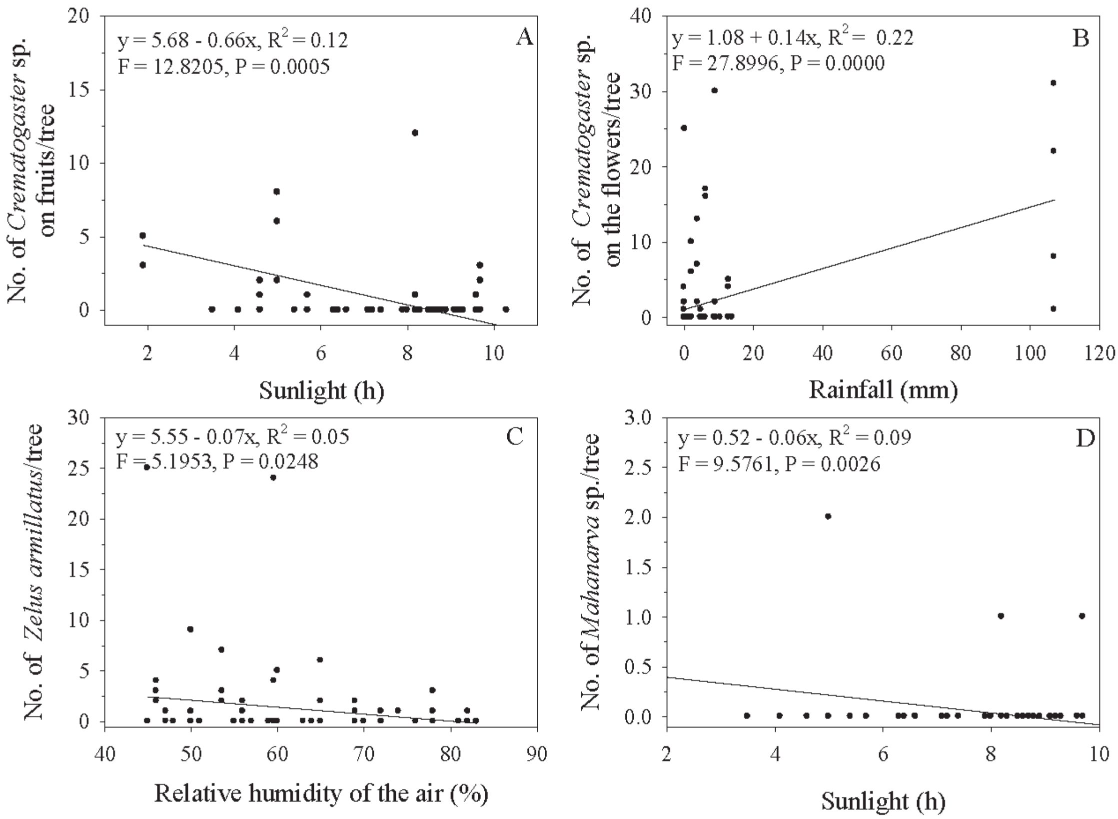

Fig. 3. Relationships between sunlight and numbers of *Crematogaster* sp.; rainfall and numbers of *Crematogaster* sp.; relative humidity of the air and numbers of *Zelus armillatus*, and sunlight and numbers of *Mahanarva* sp., on *Caryocar brasiliense* trees in Montes Claros, Minas Gerais State, Brazil. Samples = 100

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 pests. Sprouting of leaves and flower development before the rainy period is common in perennial plants of the Cerrado (Almeida et al. 1998; Felfini et al. 1999; Pedroni et al. 2002; Almeida et al. 2006; Leite et al. 2006a). This allows plants to increase photosynthetic area when the efficiency of herbivory by insects is lower. In addition, there are no heavy rains during this period, and the low quantity of leaves facilitates the ability of pollinators to find *C. brasiliense* flowers such as observed by Felfini et al. (1999) with *Stryphnodendron adstringens* (Mart.) Coville (Fabaceae).

In the spring *C. brasiliense* has new and fully expanded leaves (Leite et al. 2006a) and the weather is rainier; and in spring the populations of *A. gossypii* and its predator *Chrysoperla* sp., and *Mahanarva* sp. spittlebugs were greater. Some aphids species, such as *A. gossypii*, which is considered an initial pest, could induce undesirable changes in the host plant defense physiology during development (Santos et al. 2003; Men et al. 2004; Rhainds & Messing 2005; Leite et al. 2005a, 2006b, 2007). The increase in RH is the factor responsible for breaking embryonic dormancy of *Mahanarva* sp. (Gallo et al. 2002). *Dikrella* sp. and its predator *Trybonia* sp. were also recorded in this period of new leaves, but the highest *Dikrella* sp. population occurred 5 mo later, i.e., from Mar of the next year, but decreased again in late Aug and Sep with the new leaf fall. *Holopothrips* sp. scarify leaves (Cavalleri & Kaminski 2007), create galls (Cabrera & Segarra 2008), or are predators (Almeida et al. 2006), as are the spiders, bugs of the genus *Zelus* spp. and those of the subfamily Asopinae, *Trybonia* sp., and *Chrysoperla* sp. These predators are important in different ecosystems (Molina-Rugama et al. 1998; Landis et al. 2000; Almeida et al. 2006; Mizell 2007; Oberg et al. 2008; Venturino et al. 2008; Leite et al. 2002, 2003, 2005a,b, 2006b, 2007, 2011f).

The sucking insect species with higher potential to become pests in commercial *C. brasiliense* plantations are *Aetalium reticulatum* L. treehoppers (Aetalionidae), a pest of mango; *E. rufomarginata* on flowers and fruits; *Dikrella* sp. and *A. gossypii* cited as pest in seedling of this plant specie (Leite et al. 2006c). These insects were also affected by predators on this plant. Moreover our study reinforces the importance of sucking insects and the necessity of studying population dynamics of these organisms in arboreal systems of the Cerrado.

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