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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. 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 in 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 hojas en el invierno y la primavera, mientras estaba en los frutos en la...
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 (Bridge-water 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 (Aguir & Camargo 2004). In addition, reforestation Diversity hotspot (Myers et al. 2000). The primary biodiversity, the Cerrado has been selected as a bio-

**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 5° DISMET”. 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 $v_x + 0.5$) 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 Frenquemania 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), Chrysopeola 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     |
|              | Coccinellidae     | Neocaulia fulgarata Mulsant | Predator | Rare-L     |
| Hemiptera    | Aethalionidae     | Aethalium reticulatum L | Leaves  | Rare-L     |
|              | Aleurodidae       | 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 |
|              | Geocoridae        | Epipolops sp.         | Predator | Common-L   |
|              | Membracidae       | Aconophora sp.        | Leaves  | Rare-L     |
|              |                   |                       | Flowers  | Rare-Fl    |
|              |                   |                       | Flowers  | Rare-Fl    |
|              |                   |                       | Fruits   | Rare-Fr    |
| Hymenoptera  | Formicidae        | Camponotus novograndensis Mayr | Generalist | Common-L       |
|              |                   | Cephalotes minutus (Fabr.) | Generalist | Common-L       |
|              |                   | Zelus armillatus (Lep. and Servi) | Generalist | Common-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 | Common-L       |
|              |                   | Zelus armillatus (Lep. and Servi) | Generalist | Common-L       |
|              | Neuroptera        | Chrysopidae           | Predator | Common-L   |
|              | Thysanoptera      | Phlaeothripidae       | Predator | Common-L   |
|              | Araneae           | ** Spiders            | Predator | Common-L   |
|              |                   |                       | Predator | Rare-Fl    |

*NI = none identified. ** spiders = Cheiracanthium inclusum Hentz (Miturgidae); Peucetia rubrolineata (Keyserling) (Oxyopi dae); Anelosimus sp., Achaearanea hirta (Taczanowski) (Theriidiidae); Gastrineans albipilosa Simon, Chira bicirrulaqera Soares and Camargo, Rudra umilla Mello-Leitão, Thiodina melangaster Mello-Leitão and Lyssomyrmex pauper Galano (Salticidae); Dic tyana sp. and sp.1 (Dictynidae); Tmarus sp. and sp.1 (Thomisidae); Argiope argentata (Fabr.), Gasteracantha cancriformes, Argiope sp., Paraexixia 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* | 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 |
|-----------|-------|-----------|-------|
|           |       |           |       |
|           | $F$   | $P$       | $F$   | $P$   |
| 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 |       |       |
| Crematogaster sp.-L | 6.543 | 0.00056 | Diversity index | 3.787 | 0.00396 |
| 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 | 0.00215 |
| Crematogaster sp. | 8.760 | 0.00056 | A. reticulatum-L n.s. | 1.548 | 0.20067 |
| P. termitarius-L n.s. | 1.225 | 0.03682 | A. reticulatum-Fl n.s. | 1.000 | 0.39215 |
| P. termitarius-Fl n.s. | 1.000 | 0.00245 | P. termitarius n.s. | 1.500 | 0.22185 |
| C. novograndensis-L n.s. | 1.000 | 0.39215 | A. reticulatum-L n.s. | 1.000 | 0.39215 |
| Cephalotes minutus-L n.s. | 2.087 | 0.10946 | A. reticulatum-Fl n.s. | 1.000 | 0.39215 |
| Dorymyrmex sp.-L n.s. | 2.087 | 0.00520 | A. reticulatum n.s. | 1.500 | 0.22185 |
| Spiders-L n.s. | 2.659 | 0.05465 | Aconophora sp.-L n.s. | 1.000 | 0.39215 |
| Spiders-Fl n.s. | 0.725 | 0.00265 | Aconophora sp.-Fl n.s. | 5.192 | 0.00265 |
| Spiders-Fr n.s. | 3.080 | 0.03278 | Aconophora sp.-Fr n.s. | 5.482 | 0.02483 |
| Zelus armillatus-L n.s. | 1.525 | 0.21545 | Aconophora sp.-Fr n.s. | 4.676 | 0.00520 |
| Epipolops sp.-L n.s. | 1.208 | 0.28651 | Aconophora sp.-Fr n.s. | 4.616 | 0.00520 |
| Neocalvia fulgurata-L n.s. | 2.087 | 0.00520 | Aconophora sp.-Fr n.s. | 4.616 | 0.00520 |
| Dikrella sp.-L n.s. | 10.96 | 0.00056 | Aconophora sp.-Fr n.s. | 4.616 | 0.00520 |
| Pseudococcus sp.-L n.s. | 0.04 | 0.00265 | Aconophora sp.-Fr n.s. | 4.616 | 0.00520 |
| Aphanthoglossus-L n.s. | 0.04 | 0.00265 | Aconophora sp.-Fr n.s. | 4.616 | 0.00520 |
| Bemisia tabaci-L n.s. | 0.04 | 0.00265 | Aconophora sp.-Fr n.s. | 4.616 | 0.00520 |
| Mahanarva sp.-L n.s. | 0.04 | 0.00265 | Aconophora sp.-Fr n.s. | 4.616 | 0.00520 |

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 (Hemiptera) 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 | 0.00 ± 0.00 | 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 | 0.08 ± 0.00 |
| Aconophora sp.-Fr** | 0.00 ± 0.00 B | 0.00 ± 0.00 B | 4.68 ± 2.37 A | 0.88 ± 0.28 B |
| Total Aconophora sp.-** | 0.00 ± 0.00 B | 0.08 ± 0.00 B | 0.12 ± 0.06 A | 0.00 ± 0.00 B |
| Frequenamia sp.-L** | 0.00 ± 0.00 B | 0.00 ± 0.00 B | 5.48 ± 2.48 A | 0.40 ± 0.28 B |
| Edessa rufomarginata-L n.s. | 0.00 ± 0.00 B | 0.00 ± 0.00 B | 0.08 ± 0.07 | 0.08 ± 0.05 |
| Membracidae-L n.s. | 0.00 ± 0.00 B | 0.00 ± 0.00 B | 0.00 ± 0.00 | 0.04 ± 0.03 |
| Dikrella sp.-L* | 10.96 ± 2.85 A | 10.60 ± 2.13 A | 10.60 ± 2.13 A | 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 |
| Aphid gossypii-L* | 0.04 ± 0.03 B | 0.00 ± 0.00 B | 0.12 ± 0.08 B | 0.28 ± 0.14 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 | 0.04 ± 0.03 |

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).
sucking insects, the numbers of *Trybonia* sp. Thy-
sanoptera 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 cor-
related negatively with the number of *Cremato-
gaster* sp. on fruits per tree and *Mahanarva* sp. on
the leaves per tree; rainfall correlated positively
with the number of *Crematogaster* sp. on the flow-
ers 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 de-
termined by the reduction in the number of C.

| 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** | 0.12 ± 0.06 B | 0.08 ± 0.05 B | 0.28 ± 0.10 A | 0.24 ± 0.08 |
| *P. termitarius*-Fl** | 0.04 ± 0.03 B | 0.00 ± 0.00 B | 0.00 ± 0.00 B | 0.00 ± 0.00 |
| Total *P. termitarius** | 0.16 ± 0.07 B | 0.08 ± 0.05 B | 0.28 ± 0.10 A | 0.24 ± 0.08 |
| *C. novograndensis*-L** | 0.04 ± 0.03 B | 0.04 ± 0.03 B | 0.16 ± 0.07 B | 0.04 ± 0.03 |
| *Cephalotes minutus*-L** | 0.00 ± 0.00 B | 0.00 ± 0.00 B | 0.08 ± 0.05 B | 0.00 ± 0.00 |
| *Dorymyrmex* sp.*| 0.00 ± 0.00 B | 0.00 ± 0.00 B | 0.08 ± 0.05 B | 0.00 ± 0.00 |
| *Epipolops* sp.-Ln.s. | 0.28 ± 0.16 B | 0.36 ± 0.12 B | 0.08 ± 0.07 B | 0.12 ± 0.08 |
| *Chrysoperla* sp.-Ln.s. | 0.32 ± 0.14 B | 1.44 ± 0.97 B | 2.12 ± 1.05 B | 0.72 ± 0.30 |
| *Neocalvia fulgurate*-Ln.s. | 0.00 ± 0.00 B | 0.28 ± 0.28 B | 0.28 ± 0.13 B | 0.04 ± 0.03 |
| *Calosoma* sp.-Ln.s. | 5.15 ± 0.73 B | 1.04 ± 0.35 B | 1.03 ± 0.40 B | 22.48 ± 7.59 A |
| *Holopothrips* sp.-Ln.s. | 0.24 ± 0.10 B | 0.40 ± 0.12 B | 0.40 ± 0.12 B | 0.40 ± 0.11 |
| *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 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 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 | Summer | Autumn | Winter | Spring |
| Temperature | 24.10 ± 0.11 B | 22.16 ± 0.30 C | 22.78 ± 0.23 C | 25.05 ± 0.27 A |
| Rainfall** | 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

| Variables | Sumner | Autumn | Winter | Spring |
|---|---|---|---|---|
| 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).
*Caryocar 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. *Crema togaster* sp. ants were also more abundant during
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. 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.
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 (Cavaleri & 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 species (Leite et al. 2006c). These insects were also affected by predators on this plant. Moreover our study re-

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![Graphs showing relationships between sunlight, rainfall, and humidity and insect population](https://example.com/graphs)
inforces 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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