Diversity of Hemiptera (Arthropoda: Insecta) and Their Natural Enemies on Caryocar brasiliense (Malpighiales: Caryocaraceae) Trees in the Brazilian Cerrado

Authors: Leite, Germano Leão Demolin, Veloso, Ronnie Von dos Santos, Zanuncio, José Cola, Alonso, Jatnel, Ferreira, Paulo Sérgio Fiuza, et al.

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Diversity of Hemiptera (Arthropoda: Insecta) and their natural enemies on *Caryocar brasiliense* (Malpighiales: Caryocaraceae) trees in the Brazilian Cerrado

Germano Leão Demolin Leite[1,], Ronnie Von dos Santos Veloso[2], José Cola Zanuncio[2], Jatnel Alonso[3], Paulo Sérgio Fiuza Ferreira[2], Chrystian Iezid Maia Almeida[1], Geraldo Wilson Fernandes[4], and José Eduardo Serrão[5]*

Abstract

The Cerrado occupies about 23% of the Brazilian territory and is characterized by great diversity of plants and insects and a great degree of endemism, and *Caryocar brasiliense* A. St.-Hil. (Malpighiales: Caryocaraceae) is widely distributed in this region. The diversity and abundance of hemipterans and their natural enemies were studied on trees of *C. brasiliense* in the Cerrado, pasture, and anthropic area in Montes Claros, Minas Gerais State, Brazil. We observed 1 rare, 8 common, and 1 frequent species of sucking insects; and 2 rare, 7 common, and 6 frequent species of natural enemies. Sucking insects and their natural enemies were most abundant in the pasture and least abundant in the Cerrado. Increasing diversity indices and numbers of species and individuals of sucking insects were followed by similar trends in the populations of natural enemies. Increasing populations of sucking insects led to greater numbers of individuals of ants, green lacewings, predator thrips, and ladybeetles. Aluminum level positively affected the number of species and individuals, and the pH of the soil reduced those of sucking insects. Leafhoppers had greater numbers on plants on soils with low pH values and high aluminum levels, but the opposite was noted for the aphids.

Key Words: aphid; leafhopper; mealybug; predator; pequi

Resumen

Lo Cerrado ocupa alrededor del 23% del territorio brasileño y se caracteriza por una gran diversidad de plantas y de insectos y un alto grado de endemismo, y *Caryocar brasiliense* A. St.-Hil. (Malpighiales: Caryocaraceae) está ampliamente distribuido en esta región. La diversidad y abundancia de Hemiptera y sus enemigos naturales fueron estudiados en los árboles de *C. brasiliense* en el Cerrado, pastos, y en el área antrópica, en Montes Claros, Minas Gerais, Brasil. Una rara, ocho comunes, y una especie constantes de los insectos chupadores, y dos raros, siete comunes, y seis especies constantes de enemigos naturales fueron observados. Insectos chupadores y enemigos naturales fueron más abundantes en los pastos y menos abundantes en el Cerrado. Mayor número de especies de insectos chupadores y sus enemigos naturales fueron encontrados en el pasto que en el Cerrado. El aumento de índice de diversidad, número de especies y individuos de insectos chupadores fueron seguidos por un comportamiento similar de los enemigos naturales. El aumento de las poblaciones de insectos chupadores condujeron a un mayor número de individuos de hormigas, crisopa verde, depredadores de trips y mariquitas. Nivel de aluminio afectó positivamente el número de especies e individuos, y el pH del suelo reduce las de los insectos chupadores. Las chicharritas había un mayor número de plantas sobre suelos con un pH más bajo y el nivel de aluminio superior, sino todo lo contrario se observó para los pulgones.

Palabras Clave: pulgones; chicharritas; cochinillas; depredadores; pequi

Caryocar brasiliense A. St.-Hil. (Malpighiales: Caryocaraceae) trees have a wide distribution in the Brazilian Cerrado (Brandão & Gavilanes 1992; Bridgewater et al. 2004; Leite et al. 2006a) and can form a canopy of over 10 m height and 6 m width (Leite et al. 2006a, 2011a,b, 2012). The fruits have a mesocarp rich in oil, vitamins, and proteins and contain many compounds of medicinal importance. The tree is also used by humans for food, the production of cosmetics and lubricants, and in the pharmaceutical industry (Araújo 1995; Segall et al. 2005; Ferreira & Junqueira 2007; Garcia et al. 2007; Khouri et al. 2007). This plant is the main source of income in many communities (Leite et al. 2006a).

Caryocar brasiliense trees are protected by Brazilian laws and thus left in deforested areas of the Cerrado. However, in northern Minas Gerais State, in general, their natural regeneration is restricted to areas with impoverished soils (sandy or rocky outcrop) (Leite et al. 2006a). Isolated trees suffer high leaf, flower, and fruit damage from sucking insects (personal communication from collectors of fruits), but this damage is poorly studied (Araújo 1995), mainly due to lack of specialists (Freitas & Oliveira 1996; Oliveira 1997; Lopes et al. 2003; Boiça et al. 2004; Leite et al. 2009, 2011a,b, 2012).

[1]Insetário G.W.G. de Moraes, Instituto de Ciências Agrárias, Universidade Federal de Minas Gerais, CP: 135. Montes Claros, Minas Gerais, Brasil
[2]Departamento de Entomologia, Universidade Federal de Viçosa, 36571-000, Viçosa, Minas Gerais, Brasil
[3]Instituto de Ciencia Animal, Apartado Postal 24, San José de las Lajas, La Habana, Cuba
[4]Departamento de Biologia Geral, Universidade Federal de Minas Gerais, Belo Horizonte, Minas Gerais, Brasil
[5]Departamento de Biologia Geral, Universidade Federal de Viçosa, 36571-000, Viçosa, Minas Gerais, Brasil
*Corresponding author; E-mail: germano.demolin@gmail.com

The diversity and abundance of arthropods can vary among environments, and several hypotheses can explain this fact: 1) complex environments increase the number of herbivore species and their predators associated with a host plant and, generally, decrease their abundance (Auslander et al. 2003; Lazo et al. 2007); 2) host plant attributes such as complex architecture can increase the diversity of herbivorous insects (Espírito-Santo et al. 2007); and 3) soil characteristics that are favorable to trees can indirectly effect herbivorous insects (e.g., through nutritional quality) (Auslander et al. 2003; Espírito-Santo et al. 2007).

We tested, for the first time, these 3 hypotheses—complex environments, host plant attributes, and soil characteristics—in relation to the diversity and abundance of Hemiptera herbivores and their natural enemies on *C. brasiliense* trees in 3 areas. Each area represented unique habitat conditions: 1) preserved Cerrado, 2) Cerrado cleaned for pasture, and 3) Cerrado converted to urban development, i.e., an anthropic area (a university campus).

Materials and Methods

STUDY SITES

The study was conducted in the municipality of Montes Claros, Minas Gerais State, Brazil, during 3 consecutive years (Jun 2008 through Jun 2011) in 3 areas of a region with dry winters, rainy summers, and Aw climate (tropical savanna) according to Köppen (Vianello & Alves 2000). The areas were: 1) Cerrado sensu stricto (16.7487778°S, 43.9186944°W, at 943 m, with dystrophic red yellow latosol of sandy texture); 2) pasture, formerly Cerrado vegetation (16.7711389°S, 43.9587222°W, at 940 m, with dystrophic red yellow latosol of loamy texture), and 3) anthropic area, campus of the "Instituto de Ciências Agrárias da Universidade Federal de Minas Gerais" (16.6818056°S, 43.8407778°W, at 633 m, with dystrophic red latosol of medium texture) (Leite et al. 2006a, 2011a), near to a vegetable production area (approx. 400 m distance). We used the soil data already published by Leite et al. (2006a, 2011a), who had collected soil samples in the same areas.

The Cerrado sensu stricto (a species-rich dense scrub of shrubs and trees, 8–10 m in height, with a dense understory), common for the Brazilian Cerrado, is an open grassland (Ribeiro & Walter 1998; Durigan et al. 2002). The Cerrado area of our study had 44.87% grass (soil covering), 5.78% shrubs, 23.51% small trees, 8.76% big trees, and 17.00% *C. brasiliense* trees per ha. The pasture area had 84.19% grass (soil covering) (*Brachiaria decumbens* Stapf; Poales: Poaceae), 0.19% shrubs, 4.76% small trees, 2.76% big trees, and 42.30% *C. brasiliense* trees per ha. The anthropic area had 100% grass (soil covering) (*Paspalum notatum* Flüggé) and 100 *C. brasiliense* trees per ha (for detailed description of the sites see Leite et al. 2006a, 2011a).

Mature *C. brasiliense* trees were 4.07 ± 0.18 m high (mean ± standard error) with a crown width of 2.87 ± 0.13 m in the Cerrado; 5.20 ± 0.18 m high with a crown width of 3.96 ± 0.14 m in the pasture; and 3.79 ± 0.15 m high with a crown width of 1.66 ± 0.13 m in the anthropic area (Leite et al. 2006a, 2011a). We used the plant data already published by Leite et al. (2006a, 2011a) and collected from the same plants and areas.

Leaves of *C. brasiliense* are alternate, trifoliate, and with high trichome density; flowers are hermaphrodite but mostly cross-pollinated (Araújo 1995). Fruit production is annual, and *C. brasiliense* trees bloom between Jul and Sep (dry period) with fructification from Oct to Jan (rainy season) (Leite et al. 2006a). Fruits are a drupe with 1 to 4 seeds, weigh 158.49 ± 8.14 g (fresh weigh), and have a volume of 314.90 ± 20.93 cm^3 (Leite et al. 2006a).

STUDY DESIGN

The design was completely randomized with 12 replications (1 tree per replicate) and 3 treatments (areas). *Caryocar brasiliense* trees were identified in a 600 m straight line per area, and every 50 m a random plant was evaluated. Mature trees of *C. brasiliense* (producing fruits) were randomly sampled per collection, except in the anthropic area, where trees were evaluated every time.

The number of Hemiptera and arthropod natural enemies was evaluated monthly in the morning on 4 leaves, 4 flowers, and 4 fruits per tree and area by direct observation during 3 yr (Horowitz 1993). Insects on leaves, flowers, and fruits were collected with tweezers, brush, or aspirators and preserved in vials with 70% alcohol for identification.

STATISTICAL ANALYSES

The number of sucking insects and natural enemies, species richness, and diversity were calculated per tree and area. All ecological indices were measured by calculating the dataset of taxa by samples in BioDiversity Pro Version 2 software. Hill's formula (Hill 1973) was used to calculate the diversity and the Simpson indices for abundance and species richness (Lazo et al. 2007). Species of sucking insects and natural enemies were classified as: a) frequent (frequency ≥ 50%), b) common (10% < frequency ≤ 49%), and c) rare (frequency ≤ 10%) in the samples.

Simple regression analyses were made to compare the diversity index, number of individuals. and number of species of sucking insects with the diversity index, number of individuals, and number of species of natural enemies; the numbers of ants, predator thrips and bugs, spiders, ladybeetles, and green lacewings with those of sucking insects; and the chemical characteristics of the soils (Leite et al. 2006a) and

Table 1. Hill's diversity index, number of individuals, and number of species of sucking insects and their natural enemies per *Caryocar brasiliense* tree in 3 areas of Montes Claros, Minas Gerais, Brazil.

Variable	Cerrado	Anthropic area	Pasture	*F*	*P*
Sucking insects					
Diversity index	3.81 ± 0.79	4.65 ± 0.46	3.54 ± 0.43	—	n.s.
No. of individuals	11.67 ± 2.59c	44.75 ± 9.37b	86.58 ± 5.88a	38.778	<0.0001
No. of species	2.33 ± 0.44b	3.83 ± 0.32a	4.17 ± 0.50a	8.278	0.0021
Natural enemies					
Diversity index	7.47 ± 1.51	9.88 ± 0.63	7.35 ± 0.65	—	n.s.
No. of individuals	12.08 ± 0.94c	44.83 ± 4.40b	65.58 ± 5.86a	73.827	<0.0001
No. of species	4.25 ± 0.53b	5.50 ± 0.31ab	7.25 ± 0.50a	10.764	0.0006

Means (± SE) followed by the same letter in each row do not differ by the Tukey test ($P > 0.05$). Values of *F* and *P* were determined by ANOVA; n.s. = not significant by ANOVA; df = 22.

Table 2. Order, family, and species of arthropods and their feeding behavior and abundance observed on *Caryocar brasiliense* trees in Montes Claros, Minas Gerais, Brazil.

Order	Family	Species	Feeding	Abundance[a]
Coleoptera	Carabidae	*Calosoma* sp.	predator	rare-L
	Coccinellidae	*Neocalvia fulgurata* Mulsant	predator	common-L
Hemiptera	Aethalionidae	*Aethalium reticulatum* L.	leaves	rare-L
			flowers	rare-Fl
	Aleyrodidae	*Bemisia tabaci* (Gennadius)	leaves	common-L
	Aphididae	*Aphis gossypii* Glover	leaves	common-L
	Cercopidae	*Mahanarva* sp.	leaves	common-L
	Cicadellidae	*Dikrella caryocar* Coelho, Leite and Da-Silva	leaves	frequent-L
		Frequenamia sp.	leaves	common-L
	Geocoridae	*Epipolops* sp.	predator	common-L
	Membracidae	*Aconophora* sp.	leaves	common-L
			flowers	rare-Fl
			fruits	common-Fr
		unidentified species	leaves	common-L
	Pentatomidae	*Edessa rufomarginata* De Geer	leaves	common-L
	Pseudococcidae	*Pseudococcus* sp.	leaves	common-L
	Reduviidae	*Zelus armillatus* (Lepeletier and Serville)	predator	frequent-L
Hymenoptera	Formicidae	*Camponotus novogranadensis* Mayr	generalist	common-L
		Cephalotes minutus (F.)	generalist	rare-L
		Crematogaster sp.	generalist	frequent-L
			generalist	frequent-Fl
			generalist	common-Fr
		Dorymyrmex sp.	generalist	rare-L
		Pseudomyrmex termitarius (Smith)	predator	frequent-L
			predator	rare-Fr
Neuroptera	Chrysopidae	*Chrysoperla* sp.	predator	common-L
Thysanoptera	Phlaeothripidae	*Holopothrips* sp.	predator	frequent-L
		Trybonia intermedius Bagnall	predator	common-L
		Trybonia mendesi Moulton	predator	common-L
Araneae	various[b]	spiders	predator	frequent-L
			predator	common-Fl

[a] L = Leaves, Fl = flowers, and Fr = fruits.
[b] 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* Mello-Leitão (Salticidae); *Dictyna* sp. and sp.1 (Dictynidae); *Tmarus* sp. and sp.1 (Thomisidae); *Argiope argentata* (F.), *Gasteracantha cancriformis* (L.), *Argiope* sp., *Parawixia* sp. and sp.1 (Araneidae); and Anyphaenidae.

height and crown width of the plants (Leite et al. 2006a) with the numbers of sucking insects and their natural enemies. Results were subjected to analysis of variance (ANOVA) ($P < 0.05$) and simple regression analysis ($P < 0.05$) using the System of Statistical and Genetics Analysis of the Federal University of Viçosa. The effect of the areas on ecological indices and number of individuals per species of sucking insects and their natural enemies was tested with ANOVA ($P < 0.05$) and Tukey's test ($P < 0.05$), carried out using the same software.

Results

In total, 1,728 leaves, 300 flowers (Jul–Sep), and 320 fruits (Sep–Jan) of *C. brasiliense* were evaluated during the 3 yr in the 3 areas. The diversity index of sucking insects and natural enemies was similar between areas. However, sucking insects and natural enemies were more abundant in the pasture than in the Cerrado. The number of species of sucking insects and their natural enemies was greatest in the pasture and smallest in the Cerrado (Table 1). One rare, 8 common, and 1 frequent species of sucking insects and 2 rare, 7 common, and 6 frequent species of natural enemies were found on *C. brasiliense* trees (Table 2).

The numbers of the Hemiptera *Aconophora* sp. (Membracidae) on fruit peduncles and *Dikrella caryocar* Coelho, Leite and Da Silva (Coelho et al. 2014) (Cicadellidae), *Edessa rufomarginata* De Geer (Pentatomidae), *Frequenamia* sp. (Cicadellidae), and *Mahanarva* sp. (Cercopidae) on leaves of *C. brasiliense* trees were greater in the pasture than in the other areas. On the other hand, aphids, whiteflies, and a membracid (unidentified) had larger populations in the anthropic area than in the other areas (Table 3).

The number of natural enemies *Crematogaster* sp. (Hymenoptera: Formicidae) was greatest on leaves, flowers, and fruits of *C. brasiliense* trees in the pasture; those of *Epipolops* sp. (Hemiptera: Geocoridae) bugs, *Neocalvia fulgurata* Mulsant (Coleoptera: Coccinellidae) lady beetles, and *Trybonia* sp. (Thysanoptera: Phlaeothripidae) thrips on leaves, and of spiders on flowers also were greatest in the pasture (Table 4). Numbers of *Pseudomyrmex termitarius* Smith (Hymenoptera: Formicidae) ants on leaves were greatest in the Cerrado, whereas numbers of *Camponotus novogranadensis* Mayr (Hymenoptera: Formicidae) ants, green lacewings (*Chrysoperla* sp.; Neuroptera: Chrysopidae), spiders, and *Zelus armillatus* (Lepeletier & Serville) (Hemiptera: Reduviidae) bugs on leaves were greatest in the anthropic area (Table 4). *Holopothrips* sp. (Thy-

Table 3. Numbers of sucking insects on leaves (L), flowers (Fl), and fruits (Fr) per *Caryocar brasiliense* tree in 3 areas of Montes Claros, Minas Gerais, Brazil.

Sucking insects	Cerrado	Anthropic area	Pasture	*F*	*P*
Aethalium reticulatum-Fl	0.00 ± 0.00	0.00 ± 0.00	0.42 ± 0.33	—	n.s.
Aethalium reticulatum -L	0.00 ± 0.00	0.00 ± 0.00	0.17 ± 0.11	—	n.s.
Aconophora sp.-Fl	0.00 ± 0.00	0.00 ± 0.00	1.83 ± 1.08	—	n.s.
Aconophora sp.-Fr	0.00 ± 0.00b	0.00 ± 0.00b	10.33 ± 4.51a	8.398	0.0020
Aconophora sp.-L	0.58 ± 0.33	0.42 ± 0.14	1.17 ± 0.57	—	n.s.
Frequenamia sp.-L	0.00 ± 0.00b	0.00 ± 0.00b	0.42 ± 0.14a	7.857	0.0027
Edessa ruformarginata-L	0.17 ± 0.11ab	0.00 ± 0.00b	1.17 ± 0.57a	4.930	0.0170
Membracidae-L	0.00 ± 0.00b	0.42 ± 0.14a	0.00 ± 0.00b	7.857	0.0027
Dikrella caryocar-L	6.42 ± 2.00b	5.83 ± 0.82b	67.75 ± 3.47a	172.500	<0.0001
Pseudococcus sp.-L	1.25 ± 0.44	3.08 ± 1.32	2.08 ± 1.42	—	n.s.
Aphis gossypii-L	3.08 ± 1.74b	34.33 ± 8.72a	0.25 ± 0.17b	30.977	<0.0001
Bemisia tabaci-L	0.17 ± 0.11b	0.67 ± 0.18a	0.17 ± 0.11b	4.820	0.0184
Mahanarva sp.-L	0.00 ± 0.00b	0.00 ± 0.00b	0.83 ± 0.27a	11.714	0.0004

Means (± SE) followed by the same letter per row do not differ by the Tukey test ($P > 0.05$). Values of F and P were determined by ANOVA; n.s. = not significant by ANOVA; df = 22.

sanoptera: Phlaeothripidae) thrips showed lowest abundance on leaves of *C. brasiliense* trees in the Cerrado (Table 4).

The diversity index, number of species, and number of individuals of sucking insects and those values for natural enemies were positively correlated. Population increase of sucking insects was also positively correlated with that of ants, green lacewings, predator thrips, and lady beetles (Fig. 1).

Increasing level of aluminum positively affected the number of species and individuals and that of pH in the soil negatively affected the number of individuals of sucking insects on *C. brasiliense* trees (Fig. 2). Numbers of *D. caryocar* were greater on plants on soils with lower pH and higher aluminum level, but the opposite was noted for the aphids (Fig. 3).

Canopy size also influenced the abundance and diversity of sucking insects and their natural enemies. The diversity index and number of individuals of sucking insects, diversity index, number of species, and number of individuals of natural enemies (Fig. 2), number of *D. caryocar* (Fig. 3), and the number of ants, predator thrips, and lady beetles (Fig. 4) were higher on *C. brasiliense* trees with larger than on trees with smaller canopy.

Discussion

The largest number of sucking insects and their natural enemies on *C. brasiliense* trees in the pasture (versus in the Cerrado and in the anthropic area) may be explained by a combination of factors. First, the pasture environment, in our study, with *C. brasiliense* trees, grass, and other trees and shrubs had a more diversified condition than a traditional pasture (grass only) (Leite et al. 2006a, 2011a), increasing the number of sucking insect species. Second, *C. brasiliense* trees presented wider and higher crowns (complexity in the structure) in the pasture than in the other 2 areas, increasing food resources (Leite et al. 2006a). Third, soil characteristics in the pasture were most favorable to *C. brasiliense* trees—increasing their crown and consequently their fruit production (Leite et al. 2006a, 2011a, 2012), which indirectly benefitted hemipteran herbivores and natural enemies. The large numbers of aphids, whiteflies, and mealybugs and their natural enemy green lacewings on *C. brasiliense* trees in the anthropic area may be due to its proximity to vegetable production areas (i.e., okra, tomato). Environmental complexity and host plant

Table 4. Numbers of natural enemies on leaves (L), flowers (Fl), and fruits (Fr) per *Caryocar brasiliense* tree in 3 areas of Montes Claros, Minas Gerais, Brazil.

Natural enemies	Cerrado	Anthropic area	Pasture	*F*	*P*
Crematogaster sp.-Fl	1.58 ± 0.93b	0.42 ± 0.19b	19.17 ± 3.56a	45.703	<0.0001
Crematogaster sp.-Fr	0.25 ± 0.13b	0.00 ± 0.00b	6.25 ± 1.99a	14.755	<0.0001
Crematogaster sp.-L	6.33 ± 0.93b	3.67 ± 0.80b	15.17 ± 2.40a	14.214	0.0002
Pseudomyrmex termitarius-Fr	0.00 ± 0.00	0.00 ± 0.00	0.17 ± 0.11	—	n.s.
Pseudomyrmex termitarius-L	1.08 ± 0.14a	0.42 ± 0.14b	0.67 ± 0.22ab	4.724	0.0197
Cephalotes minutus-L	0.00 ± 0.00	0.00 ± 0.00	0.17 ± 0.11	—	n.s.
Dorymyrmex sp.-L	0.00 ± 0.00	0.00 ± 0.00	0.17 ± 0.11	—	n.s.
Camponotus novograndensis-L	0.00 ± 0.00b	0.33 ± 0.14a	0.00 ± 0.00b	5.500	0.0116
Holopothrips sp.-L	0.50 ± 0.15b	1.67 ± 0.41a	1.58 ± 0.25a	5.096	0.0152
Trybonia intermedius + *Trybonia mendesi*-L	0.42 ± 0.19b	0.00 ± 0.00b	14.92 ± 3.89a	51.801	<0.0001
Zelus armillatus-L	0.33 ± 0.18b	21.00 ± 2.55a	1.08 ± 0.19b	128.652	<0.0001
Epipolops sp.-L	0.25 ± 0.13b	0.00 ± 0.00b	1.92 ± 0.35a	43.223	<0.0001
Calosoma sp.-L	0.00 ± 0.00	0.00 ± 0.00	0.25 ± 0.17	—	n.s.
Neocalvia fulgurata-L	0.00 ± 0.00b	0.00 ± 0.00b	1.58 ± 0.74a	7.511	0.0033
Chrysoperla sp.-L	0.42 ± 0.19b	11.67 ± 1.52a	0.00 ± 0.00b	83.561	<0.0001
Spiders-Fl	0.00 ± 0.00b	0.00 ± 0.00b	0.42 ± 0.19a	5.013	0.0161
Spiders-L	0.92 ± 0.22c	5.67 ± 0.44a	2.08 ± 0.39b	36.564	<0.0001

Means (± SE) followed by the same letter per row do not differ by the Tukey test ($P > 0.05$). Values of F and P were determined by ANOVA; n.s. = not significant by ANOVA; df = 22.

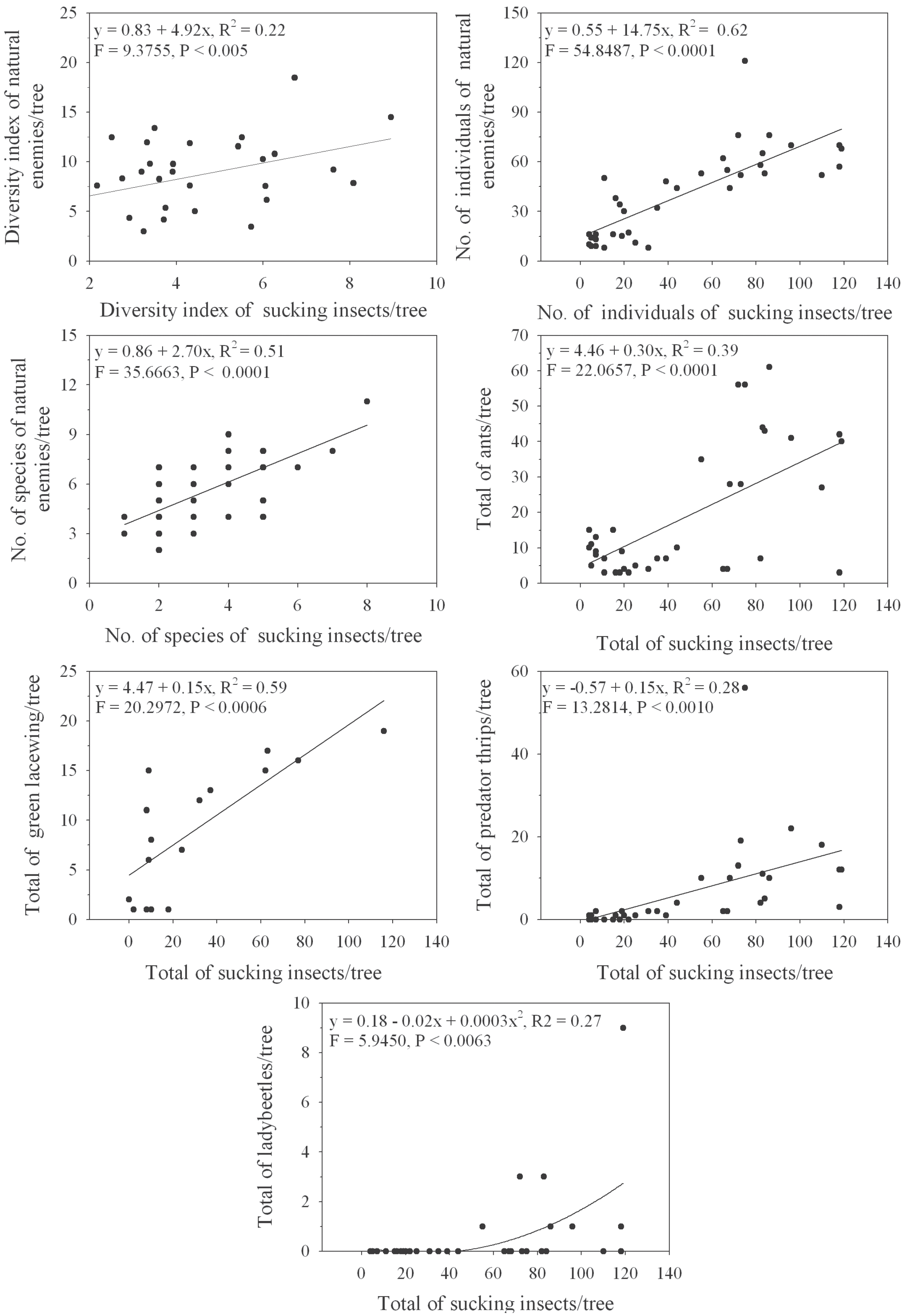

Fig. 1. Correlation of diversity indices, numbers of individuals, and numbers of species between sucking insects and their natural enemies; between number of sucking insects and total numbers of ants, green lacewings, predatory thrips, and lady beetles per *Caryocar brasiliense* tree in the 3 areas of Montes Claros, Minas Gerais, Brazil. Symbols represent the mean values.

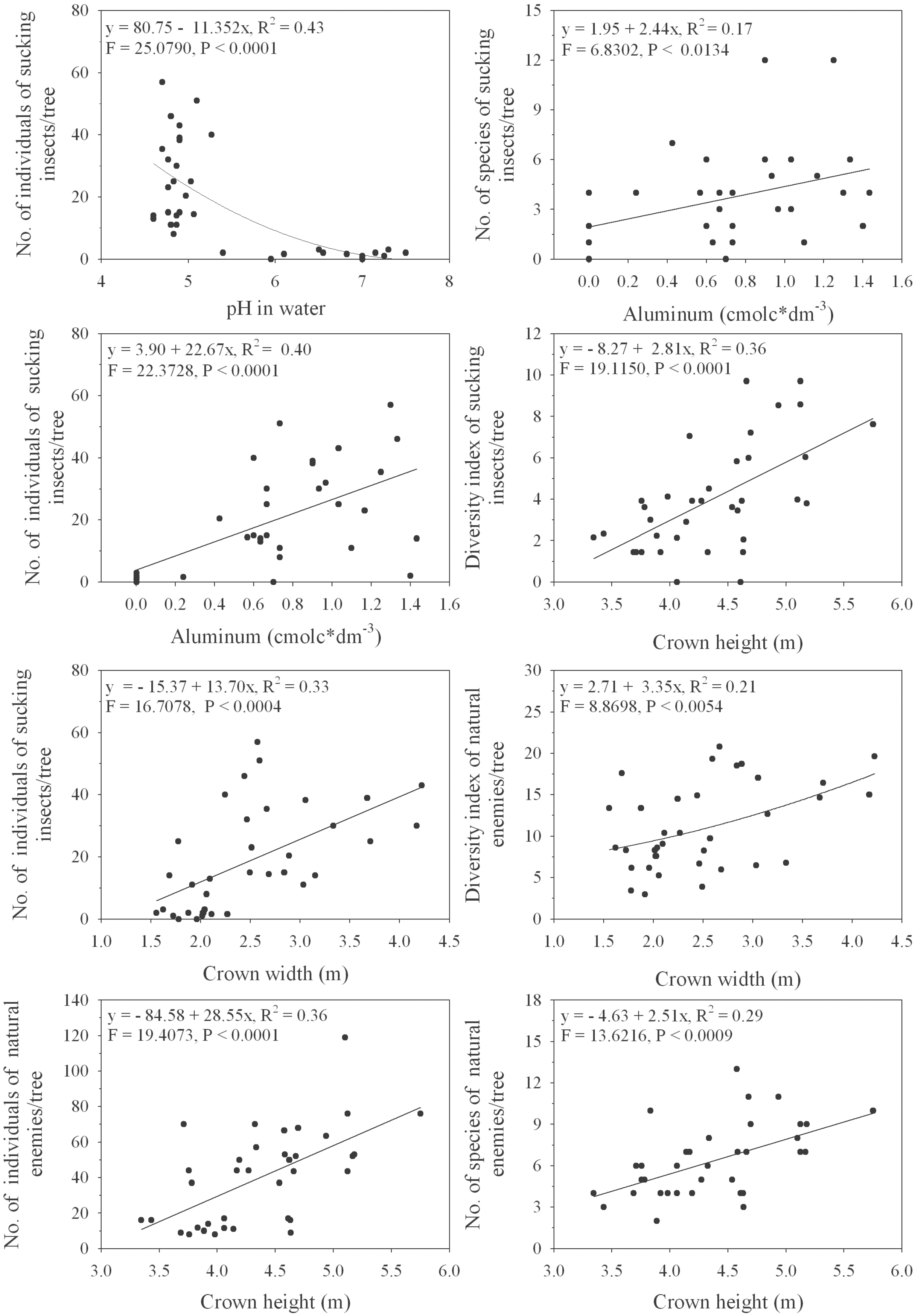

Fig. 2. Correlation of soil pH, soil aluminum level, tree height, and crown width with diversity indices, numbers of individuals, and numbers of species of sucking insects and their natural enemies per *Caryocar brasiliense* tree in the 3 areas of Montes Claros, Minas Gerais, Brazil. Symbols represent the mean values.

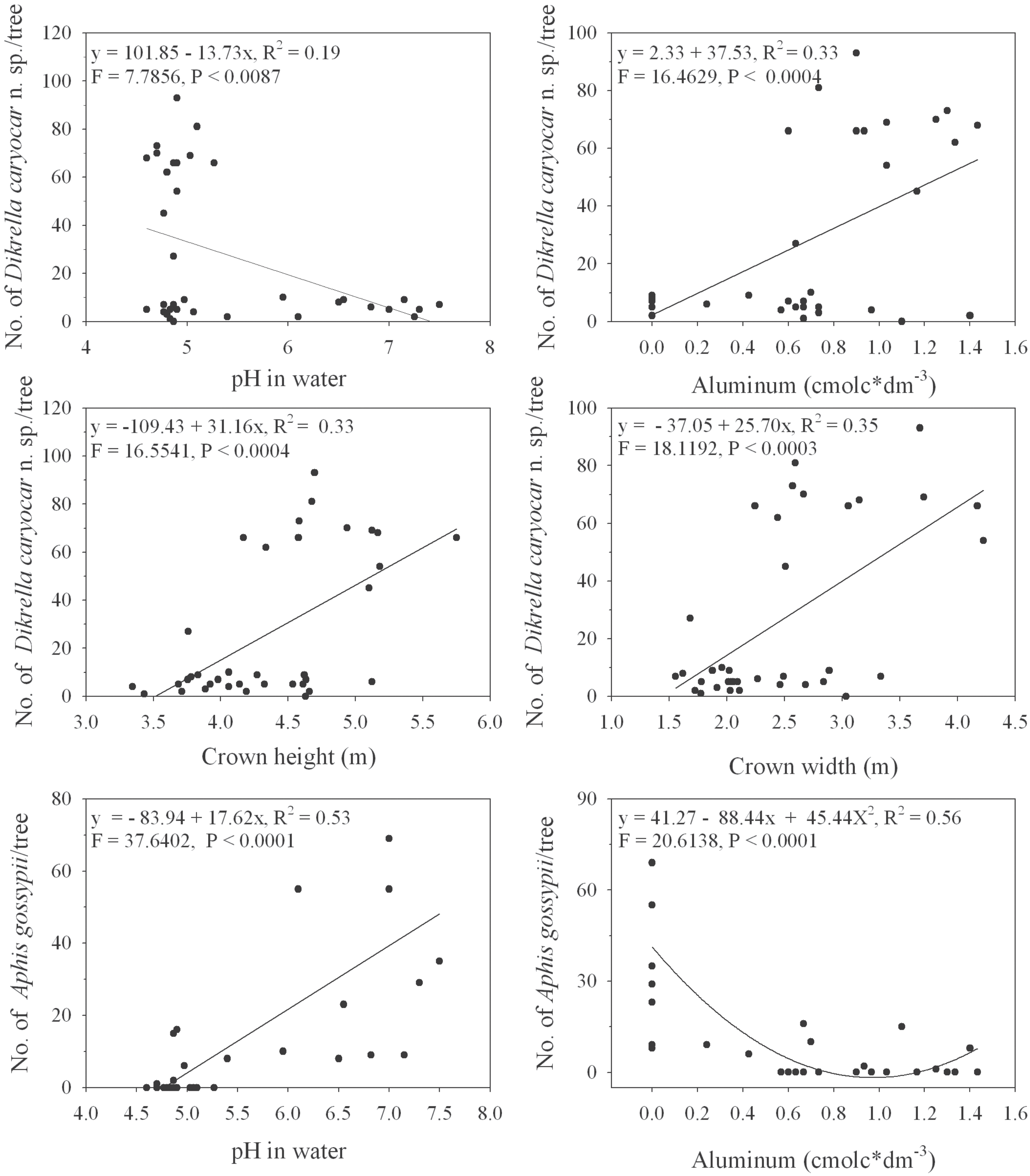

Fig. 3. Correlation of soil pH, soil aluminum level, tree height, and crown width with numbers of *Dikrella caryocar* and *Aphis gossypii* individuals per *Caryocar brasiliense* tree in the 3 areas of Montes Claros, Minas Gerais, Brazil. Symbols represent the mean values.

attributes (such as architecture and nutritional quality) influence the diversity of arthropods, both phytophagous ones and natural enemies (Auslander et al. 2003; Espírito-Santo et al. 2007; Lazo et al. 2007; Leite et al. 2011b, 2012). The number of species associated with a given host in less complex environments may be low but with generally high population abundance, hence giving herbivores pest status (Landis et al. 2000; Gonçalves-Alvim & Fernandes 2001; Gratton & Denno 2003; Coyle et al. 2005).

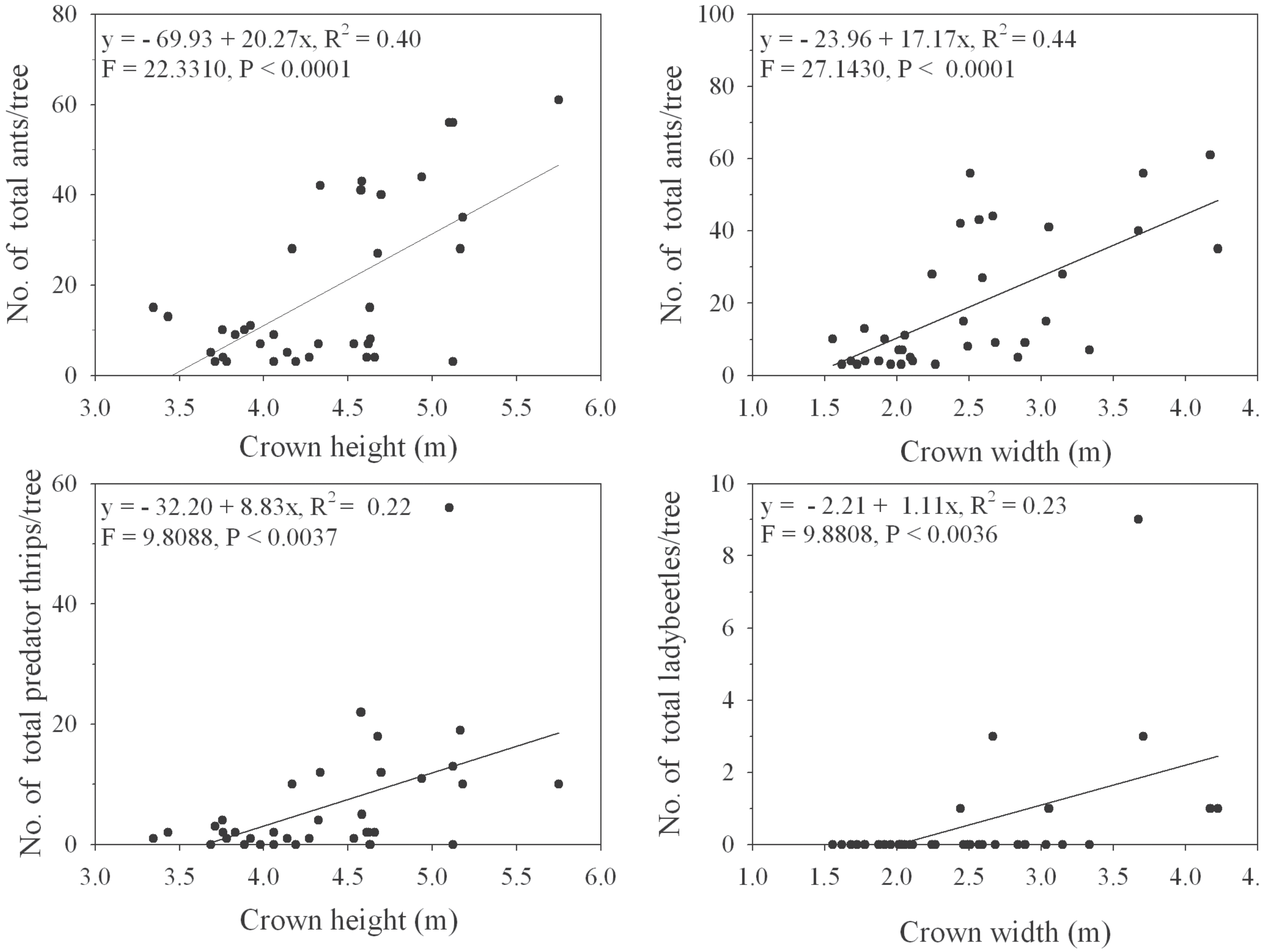

Fig. 4. Correlation between tree height and crown width with total numbers of ants, predator thrips, and lady beetles per *Caryocar brasiliense* tree in the 3 areas of Montes Claros, Minas Gerais, Brazil. Symbols represent the mean values.

The positive correlation between sucking insects on *C. brasiliense* plants with high aluminum level and acidic soils, except *Aphis gossypii* (Glover) (Hemiptera: Aphididae) (a pest of several crops), may be due to the loamier soil in the pasture than in the anthropic area (silt and compressed texture) and the Cerrado (sandy texture) (Leite et al. 2006a). Soils of the Cerrado are generally deep and loamy (excellent storage capacity for rainfall water) but poor in nutrients, rich in aluminum, and with low pH (Sousa & Lobato 2004). The soil in the pasture had higher levels of aluminum and lower pH values along with lower levels of calcium, potassium, and magnesium than soil in the anthropic area (Leite et al. 2006a). *Caryocar brasiliense* (Oliveira 1997; Leite et al. 2006a) and its native sucking insect species may have adapted to these conditions.

The greatest number of the predators *Z. armillatus*, *Holopothrips* sp., and spiders on *C. brasiliense* trees in the anthropic area might be due to higher number of leaves galled by *Eurytoma* sp. (Hymenoptera: Eurytomidae) in these trees than in trees of the other 2 areas (unpublished data). These predators preyed on galling insects that colonize up to 70% of leaf area with galls (Leite et al. 2009). *Eurytoma* sp. and aphids are very abundant on leaves of seedlings and mature *C. brasiliense* trees in the anthropic area (Leite et al. 2006b, 2007).

The positive correlation between natural enemies and sucking insects on *C. brasiliense* trees shows that mobile predators can respond to local increase in vegetation complexity and alternative prey to effectively suppress herbivores (Auslander et al. 2003). Ants can reduce infestations by *E. rufomarginata*, *Eunica bechina* Hewitson (Lepidoptera: Nymphalidae), *Prodiplosis floricola* (Felt) (Diptera: Cecidomyiidae), and petiole gall insects (Hymenoptera: Chalcidoidea) on *C. brasiliense* (Freitas & Oliveira 1996; Oliveira 1997). Also, spiders, predator bugs and thrips, green lacewings, and lady beetles are important natural enemies in various ecosystems (Landis et al. 2000; Almeida et al. 2006; Mizell 2007; Oberg et al. 2008; Venturino et al. 2008). Spiders and invertebrate predators often have a high population density in complex vegetation (plant architecture) independent of prey (Landis et al. 2000). High population density of these natural enemies was also attributed to microclimate or reduction of cannibalism and intraguild competition (Langellotto 2002).

A more diverse environment and, principally, higher structure of plant crown (complexity of the architecture) favored populations of sucking insects and of their natural enemies. The positive effect of high aluminum levels and acidic soils on sucking insects (except aphids) indicates the adaptation of these species to the Cerrado conditions. Besides, it reinforces the importance of sucking insects in arboreal systems of the Brazilian Cerrado and the necessity of studying their population dynamics.

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