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Identification of the wood-borer and the factors affecting its attack on *Caryocar brasiliense* trees in the Brazilian Savanna

Germano Leão Demolin Leite*, Sérgio Monteze Alves, Aline Fonseca Nascimento, Paulo Sérgio do Nascimento Lopes, Paulo Sérgio Fiúza Ferreira and José Cola Zanuncio

*Instituto de Ciências Agrárias, Universidade Federal de Minas Gerais, Av. Universitária, 1000, Montes Claros, Minas Gerais, Brazil. *Author for correspondence. E-mail: gldleite@ig.com.br*

ABSTRACT. The objectives of this work were to identify the wood-borer of the trunk of *Caryocar brasiliense* Camb. (Caryocaraceae) and the effects of tree size, chemical and physical soil attributes, and floristic diversity in its attack. The wood-boring caterpillar of the trunck of *C. brasiliense* belongs to the family Cossidae (Lepidoptera). The number of pupae and the amount of sawdust produced by the wood-borer per tree was higher in the pasture 1 of Montes Claros and pasture in Ibiracatu than in the other four areas (pastures and savanna in Montes Claros and savanna in Ibiracatu). The number of pupae and the amount of sawdust was highest in the trunks of trees with diameters having a breast height (DBH) more than 30 cm. This may explain the severity of attack in the areas mentioned above, which contain a higher percentage of plants with DBH> 30 cm. The soil properties also positively associate with higher attack of the wood-borer on trees when the soil is rich in potassium, calcium, magnesium, sum of bases, capacity of cationic exchange, and organic matter, while there was a negative correlation between attack and fine sand content. Systems with less floristic diversity, particularly trees of other species, may concentrate the attack of the wood-borer in the trunks of *C. Brasiliense* trees.

Keywords: pequi, soil, diameter of trunk, floristic diversity.

RESUMO. Identificação do broqueador de tronco e os fatores que afetam o seu ataque em árvores de *Caryocar brasiliense* no cerrado brasileiro. Os objetivos deste trabalho foram identificar o broqueador do tronco de *Caryocar brasiliense* Camb. (Caryocaraceae) e os efeitos de tamanho de árvore, atributos químico-físicos do solo e da diversidade florística em seu ataque. A lagarta broqueadora do tronco de *C. brasiliense* pertence à família Cossidae (Lepidoptera). O número de pupas e de serragem do broqueador por árvore foi maior na pastagem (1) em Montes Claros e pastagem em Ibiracatu do que nas outras quatro áreas (pastagens e cerrado em Montes Claros e cerrado em Ibiracatu). O número de pupas e da quantidade de serragem do broqueador foi maior em árvores cujo diâmetro de tronco na altura do peito (DAB) foi superior a 30 cm. Esse fato pode ser uma das razões para o maior ataque nas áreas mencionadas acima devido à maior percentagem de plantas com DAB > 30 cm. As propriedades do solo positivamente associadas com maior ataque do broqueador do tronco foram potássio, cálcio, magnésio, soma de bases, capacidade de troca catiônica e matéria orgânica e negativamente correlacionado com areia fina. Sistemas com menor diversidade florística, principalmente árvores de outras espécies, pode concentrar o ataque do broqueador do tronco em árvores de *C. Brasiliense*.

Palavras-chave: pequi, solo, diâmetro do tronco, diversidade florística.

Introduction

The savanna occupies about 23% of Brazilian territory with high plant diversity and is the location of the *Caryocar brasiliense* Camb. (Caryocaraceae) trees (ALMEIDA et al., 1998). The *C. brasiliense* trees can reach over ten meters in height and six meters in wide, and there is a wide size distribution of trees in the Brazilian savanna (LEITE et al., 2006, 2011).

Its fruit are used as food, cosmetics, lubricants, and within in the pharmaceutical industry (ARAÚJO, 1995), making it the main income source of many human communities (LEITE et al., 2006).

The *C. brasiliense* tree is protected by federal laws and still remains in deforested areas of the Brazilian savanna; however, this increases problems with insects (personal communication of the collectors of *C. brasiliense* fruits). Insects that damage this plant are poorly known (ARAÚJO, 1995; LEITE et al., 2007, 2009), and research is necessary to determine how to protect *C. brasiliense* trees in natural conditions (LEITE et al., 2006) and in commercial plantations.

Recently, fruit collectors have reported the death of several trees of *C. brasiliense* in savannas and pastures in northern Minas Gerais State due to the attack of a wood-borer on the trunk. However, we do not know the insect or possible factors that have increased the attack of this pest on the *C. brasiliense* trunk.

Several factors, such as size of the tree canopy (FAN et al., 2008; ITO; KOBAYASHI, 1993; McCULLOUGH; SIEGERT, 2007), environmental stresses (i.e., soil attributes) (FREDERICKS; JENKINS, 1988; HANKS et al., 1999), and floristic diversity (HEITZMAN, 2003), may affect the attack of the wood-borer in these trees.

The objectives of this work were to identify the wood-borer on the *C. brasiliense* trunks and to determine the effects of tree size, chemical and physical soil attributes, and floristic diversity on its attack.

Material and methods

This work was developed in the Municipalities of Montes Claros and Ibiracatu, Minas Gerais State, Brazil, in October 2006. The following areas were studied: one area of savanna vegetation *stricto sensu* and three areas with pastures (prior savanna) in Montes Claros and one savanna vegetation *stricto sensu* and one pasture (prior savanna) in Ibiracatu. Both municipalities have a tropical climate (Aw) according to the classification of Köppen, with dry winters and rainy summers. These areas show different characteristics of soil and floristic diversity. The geographical coordinates, altitude, soil type, physiochemical characteristics of the soil, floristic density, and height and width of the crown were obtained in the areas studied (Tables 1 and 3).

The study used six sample areas (two savannas and four pastures). The experimental design was randomized with 32 repetitions (32 trees per area) and a total of 192 *C. brasilienses* trees evaluated. We walked (~1600 m) in the middle of each area in a straight line, and every 50 m, we randomly evaluated a *C. brasiliense* tree. We calculated the percentage of hollow trunks caused by the wood-borer, counted the number of pupae and the amount of sawdust produced by this insect, and measured the height and width of the canopy as well as the trunk diameters at breast height (DBH) using a tape measure. Every 300 m, we evaluated the floristic diversity in an area of 1000 m^2, counting the number of trees groves^{-1} and shrubs. The number of herbs and the percentage of soil cover were determined within a 60 x 60 cm square at six points in each of the six 1000 m^2 areas. Larvae were collected for identification.

A total of 36 soil samples (0-20 cm deep) were collected, six samples per area, and their physical and chemical characteristics were evaluated at the Laboratory of Soil Analysis of the ICA/UFMG according to the methodology of Embrapa (1997). The samples were collected under the canopy projection of the *C. brasiliense* trees.

A regression analysis ($p < 0.05$) was applied for the wood-borer based on soil attributes and floristic diversity. Data were transformed to $\sqrt{x+0.5}$ and submitted to an analysis of variance and to the Scott-Knott test ($p < 0.05$).

Results and discussion

The wood-boring caterpillar of the trunck of the *C. brasiliense* belongs to the family Cossidae (Lepidoptera) (Figure 1A). The galleries created by the caterpillar Cossidae (Photo 1A, October 2006) are ascending and descending, in other words, longitudinal (Figure 1B); the sawdust produced by the attack is loosened (without a web) and has a clear color when new (Figure 1C) and a dark color when old. The galleries were found to range from one meter above or below the region of the collector. However, the majority of the sawdust was located in the area close to the collector and was where we observed most of the empty pupae (between January and April 2007). These empty pupae were principally observed from 0.5 to 2.0 cm above the soil but were occasionaly 6, 8, or 10 cm above the soil. In one tree, we observed 6 pupae and 25 empty holes that reached approximately 1.20 m from the collector region. We observed four *C. brasiliense* trees with very damaged trunks, three in the savanna and one tree in the pasture of Ibiracatu, that displayed between 30 and 80% hollowing of the trunk and had clearly visible internal and external galleries (Figure 1D). Ong'amo et al. (2006) reported that in Kenya, wild host plants of the family Cossidae migrate to crops of maize and sorghum, causing economic losses. The species *Holcocerus hippophaecolus* Hua, *Paropta paradoxa* H.-Schaeff, *Cossus Cossus* L. and *Coryphodema tristis* Drury bore the trunk of *Hippophae rhamnoides* L. in China (FANG et al., 2005), fig trees in Egypt (SHEHATA et al., 1999), apples and pears in Italy (FACCIOLI et al., 1993), and eucalyptus in South Africa (GEBEYEHU et al., 2005).

We observed the following percentage of plants attacked by Cossidae: in the savanna (0.0%), and in pasture 1 (40.9%), pasture 2 (15.5%), and pasture 3 (13.6%) of Montes Claros and in savanna (25.0%) and pasture (35.0%) in Ibiracatu. The percentage of trees with less than 30 cm of DBH in these 6 areas was 83.3, 44.2, 56.3, 81.8, 70.0, and 55.0%, respectively. These results may reflect a dependence of the DBHs of the *C. brasiliense* trees in these areas because 15.0% of the plants with less than 30 cm of DBH were attacked by Cossidae, compared to 38.5% of the plants with more than 30 cm DBH.

The number of pupae and the amount of sawdust created by the wood-borer per *C. Brasiliense* tree was higher in the pasture (1) of Montes Claros and Ibiracatu than in other areas, showing that the trees in the savanna of Montes Claros were not attacked (Table 1).

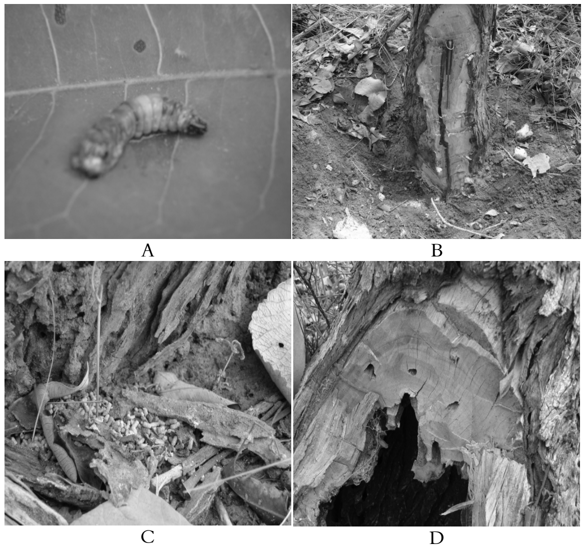

Figure 1. (A) Caterpillar Cossidae (Lepidoptera). (B) Detail of the wood-boring in a live trunk. (C) Recent sawdust. (D) Detail of the wood-boring in a dead trunk.

On the other hand, a higher occurrence of trees with damage trunk (% of hollow trunk) was observed in the savanna of Ibiracatu (Table 1). We did not detect a significant effect of height and width of the *C. brasiliense* canopy on the number of pupae and the amount of sawdust produced by the wood-borer in the areas studied (Table 2). However, the number of pupae and the amount of sawdust was higher in the trunks of trees with DBH more than 30 cm. The trees with the largest height and width of canopy and DBH, as well as a higher frequency of large size plants were located in pasture 1 of Montes Claros and the savanna and pasture in Ibiracatu. Moreover, trees with smaller sizes and higher frequencies of small plants were found in the savanna of Montes Claros (Tables 1 and 2).

One of the primary factors for the success of colonization of the wood-borer on *C. brasiliense* trunk is a DBH greater than 30 cm. The majority of the *C. brasiliense* trees are old, with large DBH, and a few are in a vegetative stage (LEITE et al., 2006). The preference of Cossidae larvae for trees with large-diameter trunks may be due to increased food resources and the greater time of exposure to attack (number of generations), as observed for other trunk wood-borers (FAN et al., 2008; ITO; KOBAYASHI, 1993; McCULLOUGH; SIEGERT, 2007; ZANUNCIO et al., 2002). In addition, older trees may have fewer secondary compounds that confer resistance to wood-borer attack, and the loss of this compound may attract this insect (FAN et al., 2008; FREDERICKS; JENKINS, 1988).

The soil properties positively associated with higher amount of pupae and sawdust in *C. brasiliense* trees were potassium, calcium, magnesium, sum of bases, capacity of cationic exchange, and organic matter, while fine sand was negatively associated with pupae and sawdust (Figures 2 and 3).

The floristic diversity also affects the attack of this insect on *C. Brasiliense* trunks. We observed a positive correlation between the percentage soil cover by plants with the number of pupae and the amount of sawdust. There were negative correlations between shrubs and sawdust as well as trees groves^{-1} and pupae (Figures 2 and 3). The highest values of potassium, sum of bases, capacity of cationic exchange, and organic matter in the soil were observed in pasture 1 of Montes Claros; the highest values of calcium were found in the pastures (Tables 1 and 2) of Montes Claros and in the pasture of Ibiracatu; the lowest value of magnesium were found in the savanna and pasture 3 of Montes Claros; and the lowest quantity of fine sandy was found in pasture 1 of Montes Claros and the pasture of Ibiracatu (Table 3).

Table 1. Coordinates and altitude of the areas examined, percentage of hollow trunks, number of pupae and amount of sawdust per tree, data for density ha^{-1}, height (m) and width (m) of the crown, and diameter at breast height (DBH) (cm) of trees ha^{-1}, soil covered per plant (%), number of herbs (< 0.50 m high), shrubs (0.50 – 2.0 m high) and trees groves^{-1} (> 2.0 m high) ha^{-1} in six areas of the Municipalities of Montes Claros and Ibiracatu, Minas Gerais State, Brazil.

	Montes Claros				Ibiracatu	
Parameters evaluated	Savanna	Pasture 1	Pasture 2	Pasture 3	Savanna	Pasture
Longitude	43° 55' 7.3" W	43° 57' 31.4" W	43° 53' 21.6" W	43° 53' 27.4" W	44° 09' 38.2" W	44° 10' 25.8" W
Latitude	16° 44' 55.6"S	16° 46' 16.1"S	16° 53' 45.2"S	16° 53' 42.1"S	15° 42' 29.5"S	15° 41' 35.5"S
Altitude	943 m	940 m	999 m	1009 m	817 m	806 m
Hollow trunks (%)	0.00 B	0.00 B	0.00 B	0.68 B	8.50 A	0.00 B
Number of pupae tree^{-1}	0.00 B	0.26 A	0.03 B	0.14 B	0.00 B	0.30 A
Number of sawdust tree^{-1}	0.00 B	0.84 A	0.19 B	0.30 B	0.10 B	0.55 A
Density of *C. brasiliense* ha^{-1}	17.00 B	42.30 A	36.50 A	45.80 A	53.16 A	33.00 A
Height of the crown of *C. brasiliense*	4.07 B	6.89 A	4.04 B	5.06 B	6.31 A	6.86 A
Width of the crown of *C. brasiliense*	2.87 C	6.87 A	4.73 B	5.89 B	6.08 A	7.11 A
DBH of *C. brasiliense*	17.53 B	28.45 A	21.95 B	18.57 B	27.26 A	26.63 A
Soil covering (%)	44.87 C	84.19 A	30.83 C	53.33 B	11.67 D	99.33 A
Herbs	5.78 C	0.19 E	11.67 B	10.33 B	3.33 D	30.00 A
Shrups	23.51 C	4.76 D	38.00 C	79.00 B	121.33 A	1.33 D
Trees groves^{-1}	8.76 B	2.76 C	6.50 B	14.00 B	40.33 A	1.00 C

*Means followed by the same letter per line do not differ between them by the Scott-Knott test at 5% probability.

The lowest density of *C. Brasiliense* trees ha^{-1} was observed in the savanna in Montes Claros (Table 1). Moreover, a higher number of trees groves^{-1} of other species and shrubs were noted in the savanna in Ibiracatu, and a higher percentage of cover of soil by plants (less bare soil) was observed in pasture 1 in Montes Claros and the pasture in Ibiracatu (Table 1).

Table 2. Hollow trunk (%), number of pupae and amount of sawdust produced by the wood-borer/total tree or damaged tree (brackets), and frequency (%) of these trees per category in six areas of the Municipalities of Montes Claros and Ibiracatu, Minas Gerais State, Brazil.

	Category per height of the crown of *Caryocar brasiliense* (m)					
	0.50 – 1.99	2.00 – 2.99	3.00 – 4.99	5.00 – 6.99	7.00 – 8.99	> 9.00
Hollow trunks (%)*	0.00	0.00	0.00	1.36	4.31	0.81
Number of pupae tree^{-1}*	0.00(0.00)	0.05 (0.50)	0.09 (1.00)	0.34 (1.67)	0.04 (1.00)	0.14 (1.00)
Number of sawdust tree^{-1}*	0.00 (0.00)	0.20 (1.33)	0.24 (1.44)	0.73 (2.29)	0.21 (1.50)	0.54 (1.82)
	Frequency of *C. brasiliense* trees					
Savanna (Montes Claros)	0.00	25.00	58.33	8.33	8.33	0.00
Pasture 1 (Montes Claros)	2.33	2.33	13.95	44.19	11.63	25.58
Pasture 2 (Montes Claros)	6.25	6.25	53.13	18.75	9.38	6.25
Pasture 3 (Montes Claros)	7.58	13.64	22.73	18.18	21.21	16.67
Savanna (Ibiracatu)	0.00	10.00	30.00	20.00	15.00	25.00
Pasture (Ibiracatu)	5.00	15.00	15.00	10.00	15.00	40.00
	Category per width of the crown of *Caryocar brasiliense* (m)					
	0.80 – 1.99	2.00 – 4.99	5.00 – 6.99	7.00 – 8.99	9.0 – 10.99	> 11.00
Hollow trunk (%)*	0.00	0.00	1.43	0.00	4.70	0.00
Number of pupae tree^{-1}*	0.08 (1.00)	0.06 (1.00)	0.17 (1.00)	0.25 (2.25)	0.15 (1.25)	0.11 (1.00)
Number of sawdust tree^{-1}*	0.25 (1.15)	0.16 (1.6)	0.43 (1.6)	0.64 (1.92)	0.42 (2.33)	0.47 (2.33)
	Frequency of *C. brasiliense* trees					
Savanna (Montes Claros)	0.00	66.67	25.00	8.33	0.00	0.00
Pasture 1 (Montes Claros)	6.98	13.95	27.91	25.58	16.28	9.30
Pasture 2 (Montes Claros)	3.13	28.13	25.00	15.63	18.75	9.38
Pasture 3 (Montes Claros)	6.06	28.79	16.67	16.67	24.24	7.58
Savanna (Ibiracatu)	5.00	35.00	25.00	10.00	15.00	10.00
Pasture (Ibiracatu)	15.00	10.00	15.00	30.00	5.00	25.00
	Category per diameter of the trunk at breast height of *C. brasiliense* (cm)					
	1.00 – 9.9	10.0 – 19.9	20.0 – 29.9	30.0 – 39.9	40.0 – 59.9	> 60.0
Hollow trunk (%)*	0.00	1.18	0.00	1.29	4.78	0.00
Number of pupae tree^{-1}	0.00B(0.00)	0.06B(1.00)	0.07B(1.00)	0.23A(1.14)	0.44A(2.00)	0.29A(1.00)
Number of sawdust tree^{-1}	0.03B(1.00)	0.20B(1.25)	0.31B(1.78)	0.60A(2.10)	0.91A(2.33)	0.86A(2.00)
	Frequency of *C. brasiliense* trees					
Savanna (Montes Claros)	33.33	50.00	0.00	0.00	8.33	8.33
Pasture 1 (Montes Claros)	2.33	13.95	27.91	27.91	23.26	2.33
Pasture 2 (Montes Claros)	15.63	34.38	6.25	15.63	18.75	9.38
Pasture 3 (Montes Claros)	19.70	31.82	30.30	13.64	19.70	0.00
Savanna (Ibiracatu)	10.00	30.00	30.00	10.00	10.00	10.00
Pasture (Ibiracatu)	25.00	5.00	25.00	35.00	5.00	5.00

Means followed by the same letter per line do not differ between them by the Scott-Knott test at 5% probability. *Non significant by ANOVA ($p > 0.05$).

Table 3. Data from the physical and chemical analyses of the soil during the experimental period in the six areas of the Municipality of Montes Claros and Ibiracatu, Minas Gerais State, Brazil.

	Montes Claros				Ibiracatu	
Parameters of the soil	Savanna	Pasture 1	Pasture 2	Pasture 3	Savanna	Pasture
pH in water	4.85C	4.87C	5.40A	5.17B	5.50A	5.60A
Phosphorus-Mehlich 1 (mg* dm^{-3})	0.80C	0.59C	1.33C	4.30A	1.00C	2.63B
Phosphorus-remaining (mg* L^{-1})	40.76A	17.64D	28.30C	30.53C	35.17B	40.07A
Potassium (mg* dm^{-3})	28.25B	62.92A	7.33C	24.00B	17.00C	26.33B
Calcium (cmol$_c$* dm^{-3})	0.20B	0.71A	0.47A	0.30B	0.40B	0.50A
Magnesium (cmol$_c$* dm^{-3})	0.10B	0.37A	0.23A	0.17B	0.23A	0.30A
Aluminum (cmol$_c$* dm^{-3})	0.68B	1.06A	0.59B	0.68B	0.38C	0.39C
H + Al (cmol$_c$* dm^{-3})	5.19B	10.93A	2.93C	3.19C	2.00C	1.96C
Summ of bases (cmol$_c$* dm^{-3})	0.37C	1.23A	0.72C	0.53C	0.68C	0.87B
t (cmol$_c$* dm^{-3})**	1.05B	2.30A	1.31B	1.21B	1.06B	1.26B
m (%)**	63.58A	47.75B	52.67B	58.00A	36.67C	32.33C
T (cmol$_c$* dm^{-3})**	5.56B	12.17A	3.65C	3.72C	2.68C	2.82C
V (%)**	6.66D	11.08D	17.33C	13.67C	25.33B	31.33A
Organic matter (dag* kg^{-1})	1.11B	8.77A	2.33B	2.94B	2.20B	2.46B
Gross sand (dag* kg^{-1})***	20.92D	5.75E	26.27C	36.33B	32.67B	48.33A
Fine sand (dag* kg^{-1})	53.92A	30.33C	57.73A	49.67A	54.67A	40.33B
Silt (dag* kg^{-1})	10.83B	24.83A	7.33C	6.67C	7.33C	7.33C
Clay (dag* kg^{-1})	14.33B	39.00A	8.67C	7.33C	5.33D	4.00D
Texture	Sandy	Loamier	Sandy	Sandy	Sandy	Sandy
Soil classification	Dystrophic Red Yellow Latosol					

*Means followed by the same small letter per line do not differ between them by the Scott-Knott test at 1% probability. ** t= capacity of cationic exchange, m= aluminium saturation in the capacity of cationic exchange; T= cation exchange capacity at natural pH 7.0; V= percentage of soil base saturation of the capacity of cationic exchange a pH 7.0.***Gross sand (2 –0.2 mm) (dag kg^{-1}), Fine sand (0.2 – 0.02 mm) (dag kg^{-1}), Silt (0.02 – 0.002 mm) (dag kg^{-1}), Clay (< 0.002 mm) (dag kg^{-1}).

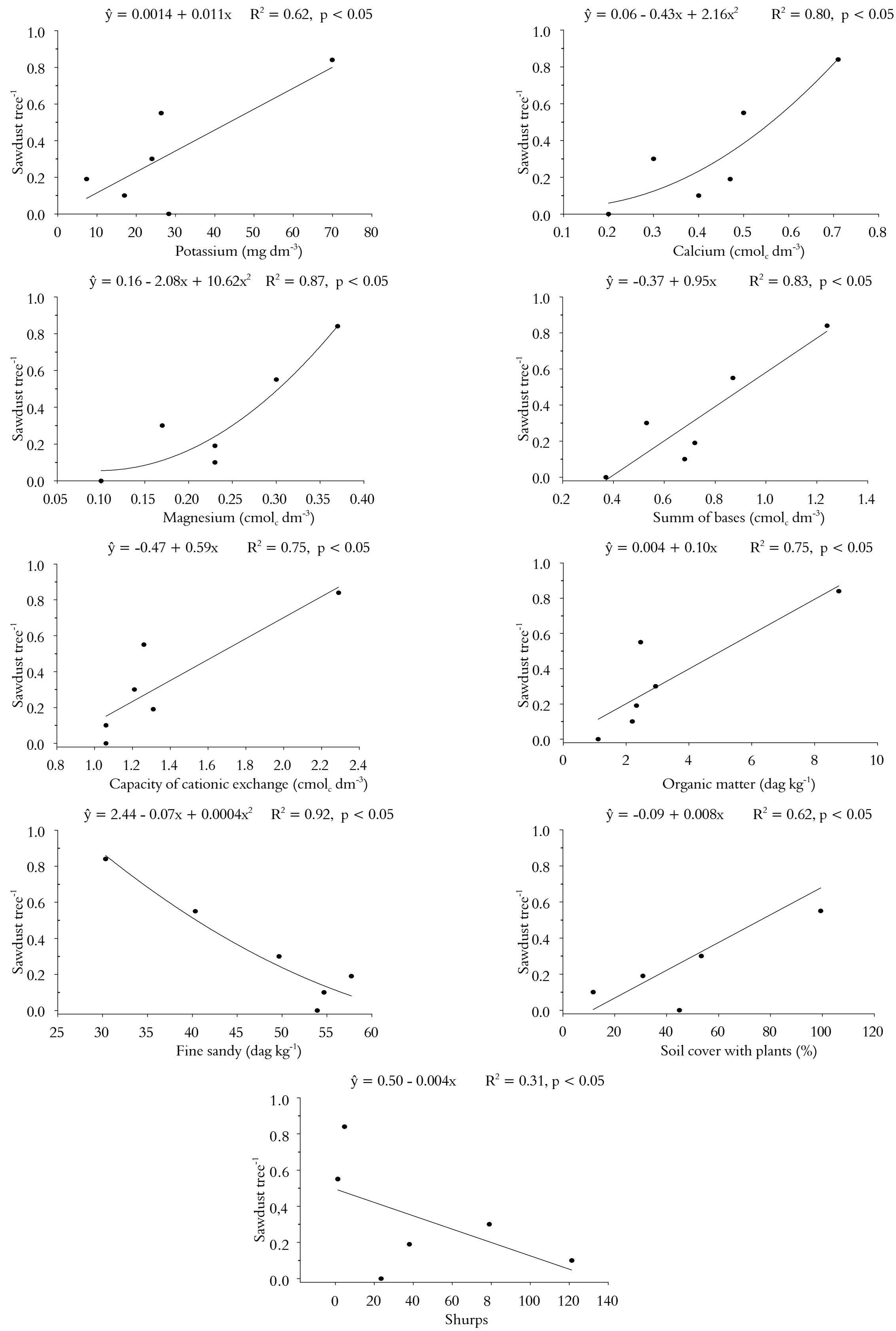

Figure 2. Effect of potassium, calcium, magnesium, sum of bases, capacity of cationic exchange, organic matter, fine sandy, soil cover by plants (%), and shrubs on the amount of sawdust of Cossidae per *C. brasiliense* tree. The symbols represent the average of 32 trees (one area).

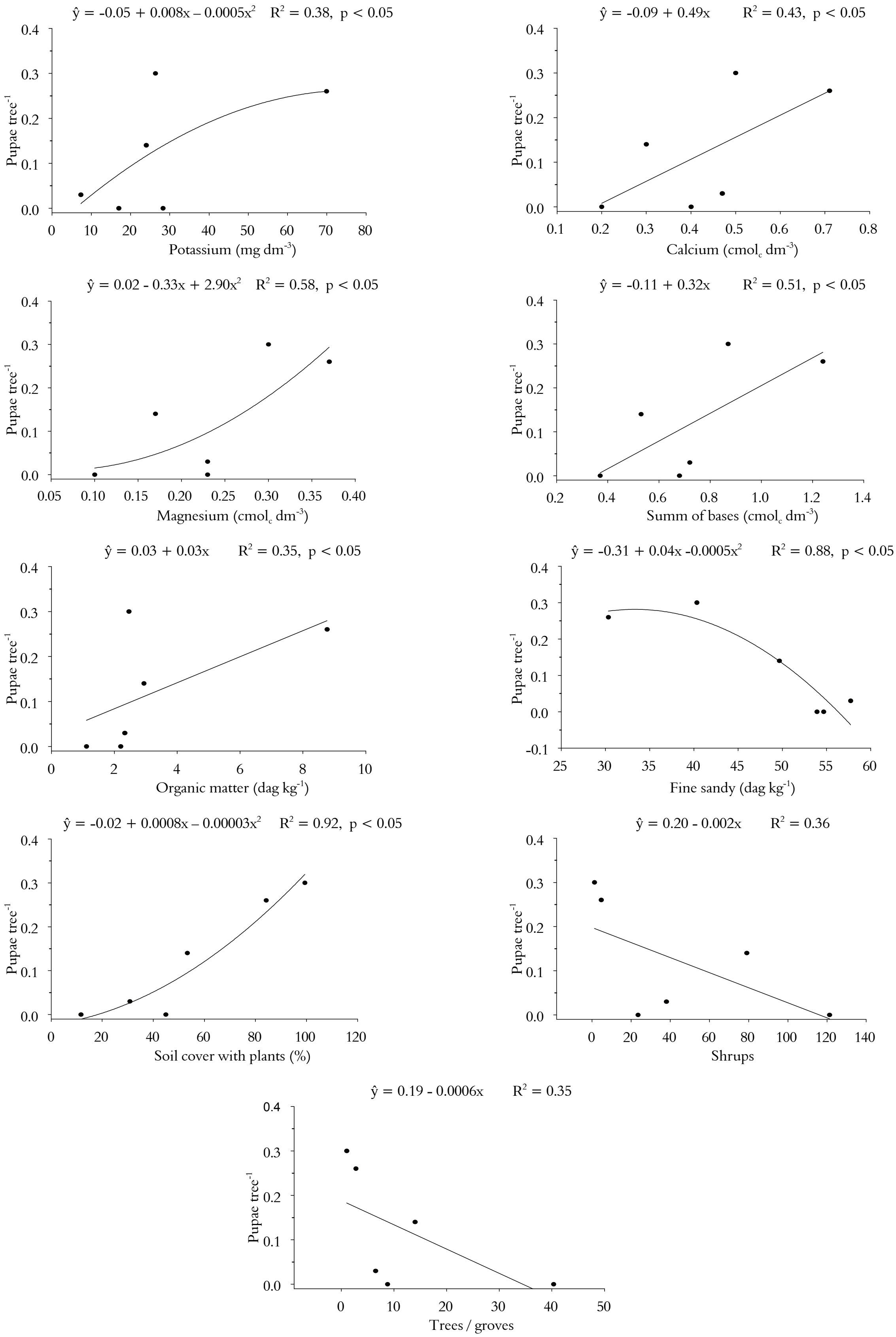

Figure 3. Effect of potassium, calcium, magnesium, sum of bases, organic matter, fine sandy, soil cover with plants (%), shrubs and trees grove^{-1} on the number of pupae of Cossidae per *Caryocar brasiliense* tree. The symbols represent the average of 32 trees (one area).

Another factor that may favour the attack of wood-borer on *C. brasiliense* trees is the properties of the soil. We noted higher wood-borer attacks in plants growing in soils richer in bases (potassium, calcium and magnesium) and with a greater capacity of cationic exchange, higher levels of organic matter, and lower amounts of fine sand. *Caryocar brasiliense* is a tree typical of the Brazilian savanna where soils are poor (LEITE et al., 2006, 2011; SOUSA; LOBATO, 2004) and, in natural conditions, this plant is expected to produce larger amount of secondary compounds that confer greater resistance against pests. On the other hand, environmental stresses, such as richer soil, predispose trees to attack by the wood-borer (FREDERICKS; JENKINS, 1988; HANKS et al., 1999).

Another key factor for the attack of the wood-borer on *C. brasiliense* plants is the floristic diversity of the environment. The two pasture areas, pasture 1 in Montes Claros and the pasture in Ibiracatu, had the lowest floristic diversity, which can reduce the tree's natural biological control and increase the food source for some species, conditions that can make a herbivore become a pest (COYLE et al., 2005; GONÇALVES-ALVIM; FERNANDES, 2001; GRATTON; DENNO, 2003; LANDIS et al., 2000). These two areas are representative of the events happening in Brazil, mainly in the North of Minas Gerais State, where deforesting of the savanna leaves few plants of the forest in the pasture and, in the case of Montes Claros and Ibiracatu municipalities, these are mainly trees of *C. brasiliense* maintained predominantly for the extraction of its fruits (LEITE et al., 2006). Because there are a few other host plants with greater trunk diameters available to the caterpillars of Cossidae, the attack of this insect focuses on plants of *C. brasiliense*, and together with the possible reduction of the natural biological control mechanism, may explain the ecological imbalance observed in this work.

This insect occurs naturally in *C. brasiliense*, and has not migrated from the eucalyptus plantations as the collectors of its fruit believed. According to Gebeyehu et al. (2005), a new pest of eucalyptus in South Africa, the wood-borer *C. tristis*, migrated from native plants and fruit crops, causing serious problems in eucalyptus plantations. The main control methods reported in the literature for the boring caterpillars (Cossidae) are the utilization of *Bacillus thuringiensis*, reducing 75.8% of the attack in orchards (SHEHATA et al., 1999; JOHNSON; WILLIAMSON, 2007) and the use of parasitic wasps of the family Ichneumonidae, such as *Eriborus applicitus* Foster (SHENG; SUN, 2006).

Conclusion

The wood-borers show higher attack rates on *C. brasiliense* trunks above 30 cm DBH and in areas of richer soils and lower floristic diversity. Therefore, it is necessary to increase the floristic diversity of the areas studied in order to reduce the incidence of insect attack in the trunk of *C. brasiliense* as well as to control the chemical and/or microbiological (i.e., fungi) conditions of these plants.

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