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Herbivorous insects in flower-buds of *Caryocar brasiliense* Camb. (Caryocaraceae), with special emphasis on Lepidoptera

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Abstract. ***Caryocar brasiliense*** Camb. (Caryocaraceae) is an economically valuable species of the central Brazilian cerrados. Despite a number of studies dealing with this tree species, very little is known about the insects that attack its flower-buds. This study presents the first field research on insects in flower-buds of ***C. brasiliense*** in two cerrado areas in the Distrito Federal, Brazil. Adult insects (Lepidoptera, Diptera and Hymenoptera) emerged from 82% of the collected inflorescences. The dipteran larvae feed on the anthers inside the flower buds. Nine lepidopteran species were found and the two most abundant species were ***Phidothrica erigens*** (Pyralidae) and an unidentified Gelechiidae. The first species was dominant in the preserved area (FAL) and the second in the fragmented and disturbed cerrado area (UnB). The proportion of these lepidopteran and their hymenopteran parasitoids varied during the flowering period, with the hymenopterans being more abundant in the preserved cerrado area.

Key words: cerrado; Diptera; Gelechiidae; Pyralidae; pequi.

Resumo. Insetos herbívoros em botões florais de *Caryocar brasiliense* **Camb. (Caryocaraceae), com ênfase especial em Lepidoptera.** ***Caryocar brasiliense*** Camb. (Caryocaraceae), é uma árvore de alta importância econômica no cerrado brasileiro e, apesar da ampla literatura sobre a espécie, as informações sobre os insetos que atacam suas estruturas reprodutivas são escassas. Apresentamos aqui o primeiro levantamento dos insetos que atacam botões florais de ***C. brasiliense*** em duas áreas do Distrito Federal, Brasil. Insetos adultos (Leplidoptera, Diptera e Hymenoptera) emergiram de 82% das inflorescências coletadas. As larvas de Diptera se alimentam das anteras no interior dos botões florais. Foram encontradas nove espécies de Lepidoptera, e as duas mais abundantes foram ***Phidothrica erigens*** (Pyralidae) e uma espécie não identificada de Gelechiidae. A espécie de Pyralidae foi dominante em uma área de cerrado preservado (FAL) e a de Gelechiidae em área de cerrado alterado e fragmentado (UnB). A proporção destas espécies e de seus himenópteros parasitóides variou durante o período de floração, sendo que os himenópteros foram mais abundantes na área preservada.

Palavras-chave: cerrado; Diptera; Gelechiidae; Pyralidae; pequi.

INTRODUCTION

Caryocar brasiliense Camb. (Caryocaraceae), known by its popular name "Pequizeiro", is a native cerrado species and is widespread in the central region of Brazil (RATTER ***et al***. 2003). It has a huge economic importance (WUNDER 1999), with special reference to its fruits that are used for food, production of cosmetics, and in the pharmaceutical industry (ARAÚJO 1995, ALMEIDA & AGOSTINI-COSTA 1998).

Flowering normally occurs at the end of the dry season and beginning of the rainy season (LEITE ***et al***. 2006), with up to 30 flowers per inflorescence. ***Caryocar brasiliense*** is self-compatible; although it has higher fruit production when crossed-pollinated. It is pollinated mainly by bats, but moths (Sphingidae)

can also act as occasional nocturnal pollinators (GRIBEL & HAY 1993). During the day the flowers are also visited by birds and insects (ROCHA ***et al***. 1991, MELO 2001).

At least 44 species of caterpillars (Lepidoptera) feed on leaves of ***C. brasiliense*** in the Distrito Federal (DINIZ ***et al***. 2001, RODOVALHO ***et al***. 2007), and are also attacked by other insects, especially cecidogens (OLIVEIRA 1997, URSO-GUIMARÃES ***et al***. 2003). In spite of the vast literature on ***C. brasiliense*** (e.g., COLLEVATTI ***et al***. 2001, SILVA ***et al***., 2001, SANTANA & NAVES 2003), there is little information on the fauna attacking its reproductive structures. Only few studies refer to herbivores in inflorescences and fruits of ***C. brasiliense***: the exposed developing buds are destroyed by a dipteran larva, ***Prodiplosis floricola*** (Felt, 1907) (Cecidomyiidae), the buds are attacked by nymphs and adults of a hemipteran, ***Edessa rufomarginata*** (DE GEER, 1773) (Pentatomidae), and the fruits by frugivorous flies (Tephritoidea), and by a caterpillar (***Carmenta*** sp., Sesiidae) (OLIVEIRA 1997, UCHOA-FERNANDES ***et al***. 2002, LOPES ***et al***. 2003). The floral buds can be damaged by ***Trigona*** spp. (Hymenoptera: Apidae) (ROCHA ***et al***. 1991, LEITE ***et al***. 2006).

The present investigation reports the composition of herbivorous insects attacking buds of ***C. brasiliense*** with special emphasis on Lepidoptera. The proportion of inflorescences attacked, and the lepidopteran fauna using these resources are compared in two areas of cerrado (preserved and disturbed) in the Distrito Federal, Brazil.

MATERIAL AND METHODS

Field work was carried out at the University of Brasilia's Experimental Farm (Fazenda Água Limpa - FAL) (15°55' S, 47°55' W) located in the Environmental Protection Area – APA Gama e Cabeça de Veado. Collections were also made in unpreserved and disturbed cerrado fragments at the campus of the University of Brasília (UnB) (15°46' S, 47°50' W), which suffer more frequent burning and contain alien plants (ASSUNÇÃO & FELFILI 2004). The vegetation in both areas is cerrado ***sensu stricto***.

Sampling was done weekly during September and October of 2003, corresponding to the end of dry season and the beginning of the rainy season in Brasília. In 2003 flowering of ***C. brasiliense*** began earlier in the preserved (FAL) than in unpreserved area (UnB).

We collected inflorescences with 10 to 15 medium-sized buds (Fig.1), from different individuals of ***C. brasliense*** in each area. The inflorescences were maintained in the laboratory for 70 days to obtain adult insects whose immature stages were, in their majority, present inside the buds. Each inflorescence had its stalk wrapped in moistened cotton and was placed in a plastic pot covered with fine cotton mesh. The number of emerged adults from each plastic pot (one inflorescence) was used as a measure of insect abundance. The adults were killed by freezing, identified to the lowest taxonomic level, and voucher specimens were deposited in the Entomological Collection of the University of Brasilia. Previously collected data from the Federal District were used to obtain information on the degree of diet specificity (DINIZ ***et al***. 2001, DINIZ & MORAIS 2002).

RESULTS AND DISCUSSION

We sampled a total of 50 plants and 142 inflorescences (86 inflorescences from 30 plants at FAL and 56 inflorescences from 20 plants at UnB).

Figure 1. Stage of flower buds of ***Caryocar brasiliense*** (Caryocaraceae) used in this study.

Adults emerged from 82% (116) of the inflorescences collected, with a small difference between sites: 87% for FAL and 73% for UnB (χ^2 = 3.55; p = 0.059). A total of 799 insects (351 lepidopterans, 417 hymenopterans and 31 dipterans) were obtained.

The dipterans and the hymenopterans were not identified. The dipteran larvae feed on the anthers inside the flower buds while the hymenopterans (Ichneumonoidea) are mainly parasites of lepidopteran larvae.

We obtained nine species in six lepidopteran families (Tab.1). The attacks on the buds were mainly caused by ***Phidotricha erigens*** RAGONOT, 1888 (Pyralidae) and an unidentified species of Gelechiidae, which were the most abundant species and the only ones that occurred in both areas (Tab.1). These species co-occurred in 35% (41/116) of the inflorescences which had emergence of adults and their caterpillars destroyed the buds impeding the development of flowers and fruits.

Table 1. Lepidopteran species found in ***Caryocar brasiliense*** flower buds, number of adults obtained on each collection site, and other host plants or plant structures in which the species was already found (Diniz et al., 2001; Diniz & Morais, 2002). Numbers after lepidopteran names correspond to the codes used in the Entomological Collection of UnB.

Caryocar brasiliense	Adults		Other host plants or other structures	
LEPIDOPTERA	FAL	UnB	Buds/Flowers	Leaves
BLASTOBASIDAE				
Blastobasidae sp. 5	1		***Palicourea***	- -
Blastobasidae sp. 10		1	***Miconia***	- -
GELECHIIDAE				
Gelechiidae sp. 39	74	90	- -	- -
LYCAENIDAE				
Olynthus essus Henrich-Schaeffer, 1853		2	***Peixotoa, Roupala***	- -
Parrhasius polibetes (Cramer, 1787)		1	***Roupala, Styrax, Vochysia***	***Arrabilea***
NOCTUIDAE				
Nola sp.		1	- -	***C. brasiliense***
PYRALIDAE				
Phidotricha erigens Ragonot, 1888	114	65	***Mimosa, Palicourea, Qualea, Salacia***	***C. brasiliense, Erythroxylum, Qualea***
Phycitinae sp. 16	1		- -	***Erythroxylum***
TORTRICIDAE				
Platynota rostrana (Walter, 1863)	1		***Amazonia, Palicourea, Peixotoa***	Several families

The two most abundant lepidopteran species in ***C. brasiliense*** buds presented differences in the adults' abundance between areas (χ^2 = 11.91; p = 0.001). The Pyralidae species was more abundant at FAL corresponding to 64% (114/179) of adults of Lepidoptera obtained in this area, and the Gelechiidae was more abundant at UnB, representing 55% (90/165) of the lepidopterans collected. The hymenopterans parasitoids were more abundant at FAL (n = 280 adults) than at UnB (n = 146 adults). Proportionally the abundance of Gelechiidae at FAL remained constant over sampling dates while the Pyralidae was more abundant in the initial collections (Fig.2a). In the fragmented cerrado area (UnB) this pattern was inverted, and the Gelechiidae was more abundant in the inflorescences from the first collection (Fig.2b). At both sites hymenopteran emergence was higher from inflorescences collected later in the flowering period, but was more abundant at FAL (Fig.2). The temporal variation indicates local differences in the use of the resource for the populations of herbivores, and suggested that the parasitoids control more strong the populations of the Pyralidae in the preserved area, in the end period of budding. The differences found in the species abundance of ***Phidotricha erigens*** (Pyralidae) and the Gelechiidae species, the main bud herbivores of ***C. brasiliense***, and of the parasitoids between the studied areas, may be due to differences in flowering phenology and in specific characteristics of the areas. FAL is located in an Environmental Protection Area of about 10,000 ha, while the study area at UnB corresponds to cerrado fragments in the city of Brasilia (Plano Piloto). Cerrado fragmentation may result in different composition of herbivores (hosts) and smaller parasite populations or in a lower richness of hymenopterans species. Whatever the causes, our results indicate a lower percentage of inflorescences attacked by herbivores at the disturbed site, and a higher relative abundance of parasitoids in the preserved area.

Two of the nine lepidopteran species were found only in ***C. brasiliense*** in the cerrados of the Distrito Federal. ***Nola*** sp. (Noctuidae) was frequent on leaves and occasionally in flower buds, while Gelechiidae

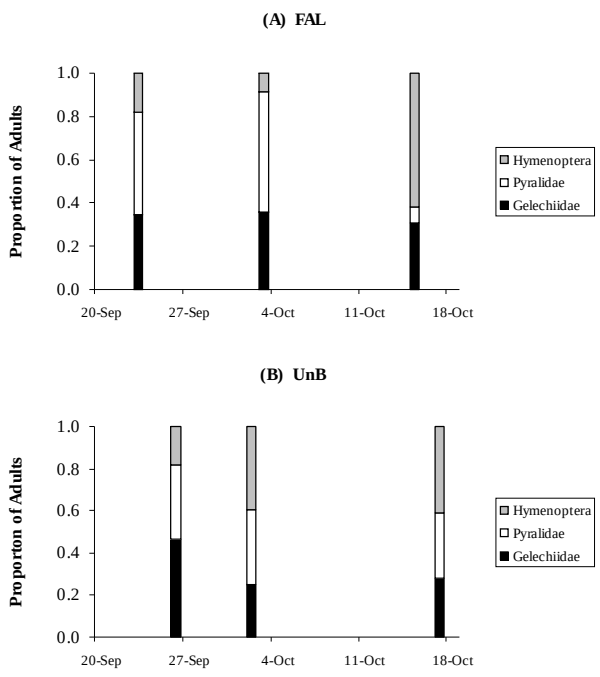

Figure 2. Proportion of adults that emerged from ***Caryocar brasiliense*** inflorescences in different collection dates in two cerrado areas of the Distrito Federal: (a) Fazenda Agua Limpa (FAL) and (b) campus of the University of Brasilia (UnB). The insects are two species of Lepidoptera (Gelechiidae and Pyralidae) and several species of Hymenoptera.

sp. 39 was frequent in flower buds and was not found on leaves of ***C. brasiliense***. The seven other species are polyphagous (Tab.1), feeding on more than one plant family: ***Phydotricha erigens*** (Pyralidae) is common on leaves of ***C. brasiliense*** and in inflorescences of other plant species; ***Platynota rostrana*** (WALTER, 1863) (Tortricidae) is among the external folivorous species with a large diet width on cerrado plant species (DINIZ ***et al***. 2001), and the Lycaenidae species were frequently found on flowers (ROBBINS & AIELLO 1982, MONTEIRO 1991, DINIZ & MORAIS 2002). The variation in the diet of caterpillars that use floral buds of ***C. brasiliense*** indicates the existence of species specialized in using inflorescences as alimentary resource, and opportunist species that are folivores but use also available inflorescences, confirming previous works (DINIZ & MORAIS 2002).

The caterpillars of the two main bud herbivores of ***C. brasiliense*** destroyed the buds impeding the development of flowers and fruits, and the dipteran larvae probably reduce the pollination efficiency by feeding on the anthers while they are still within the flower buds. Previous studies (OLIVEIRA & FREITAS 2004, LEITE ***et al***. 2006) showed the effect of wind on loss of flowers, the indirect effect of folivores and the direct effect of low soil nutrient availability as factors that can reduce fruit production in ***C. brasiliense***. Except for ***P. floricola*** (Cecidomyiidae) that destroyed developing buds (OLIVEIRA 1997), in none of these studies the direct effect of insect herbivores on loss of buds was cited. Our results indicate that endofagous herbivores can have an important direct role in the fruits and subsequent seed production of this tree.

The consequences of the floral herbivory and the Cerrado fragmentation in the reproduction of ***C. brasiliense*** still are for being investigated, and they are not part of the target of this work. However, the high ratio of inflorescences damaged, the identification of the main herbivores of floral buds in the Federal District, the temporal and spatial variation in the occurrence of the endophagous herbivores, and of its parasitoids constitute an important base of information for the continuity of inquiry of these topics. There is a large amount of information regarding herbivores of cultivated plant species, but for native species the data are still scant, even for species of recognized economic importance. These results and those in the literature indicate that ***C. brasiliense*** has a rich associated insect fauna, which also reinforces the ecological importance of this species. Its flowers, with nocturnal anthesis, are pollinated by bats and moths (GRIBEL & HAY 1993) and on the following day they are visited by a large number of species of insects and birds (MELO 2001). Its fruits are zoochoric and its leaves are used by a rich caterpillar fauna and their parasitoids (RODOVALHO ***et al***. 2007). The extra-floral nectaries are visited by a large number of ants that interact with the herbivores (OLIVEIRA & FREITAS 2004). However, populations of ***C. brasiliense*** have a high degree of inbreeding that may be partially related to habitat fragmentation (COLLEVATTI ***et al***. 2001). Thus, although protected under the law (IBAMA 1995), the high rate of fragmentation of the Cerrado and increase in extrativism of the fruits may reduce the possibility of self regeneration of this species populations in central Brazil.

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