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Biology and Occurrence of *Inga* Busk Species (Lepidoptera: Oecophoridae) on Cerrado Host Plants

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Biologia e Ocorrência de Espécies de *Inga* Busk (Lepidoptera: Oecophoridae) em Plantas Hospedeiras de Cerrado

RESUMO - Dada a ausência de informações sobre a biologia de lagartas que ocorrem em plantas de cerrado, apresentamos aqui algumas informações sobre larvas do gênero *Inga* Busk. Lagartas foram coletadas, semanalmente, em 15 indivíduos de *Diospyros burchelli* Hern. (Ebenaceae), de janeiro de 2002 a dezembro de 2003, em 30 indivíduos de *Caryocar brasiliense* Camb. (Caryocaraceae), de julho de 2003 a junho de 2004 e, em várias outras espécies de plantas desde 1991. No total foram encontradas 15 espécies de *Inga* em plantas de cerrado, no DF. Nove espécies foram raras com até cinco adultos obtidos em criação no laboratório. As outras seis espécies ocorreram durante o ano sendo mais abundantes entre maio e julho (estação seca), o que coincide com a época de maior abundância de lagartas no cerrado. As lagartas do gênero *Inga* constroem abrigos, juntando duas folhas maduras ou velhas com fios de seda, onde se alimentam e desenvolvem (um hábito comum entre os Oecophorinae). Larvas de último instar constroem, dentro do abrigo, um tipo de envelope onde completam seu desenvolvimento e empupam. A separação das espécies das lagartas é muito difícil. Características externas permitem o reconhecimento de apenas quatro espécies de *Inga*: *I. haemataula* (Meyrick), *I. phaecrossa* (Meyrick), *I. ancorata* (Walsingham), and *I. corystes* (Meyrick). Essas quatro espécies têm ampla distribuição geográfica e são polífagas. Neste artigo, apresentamos informações não encontradas na literatura sobre a história natural de seis espécies de *Inga* comuns em plantas hospedeiras de cerrado.

PALAVRAS-CHAVE: Abrigo de folhas, *Caryocar*, dieta, *Diospyros*, Oecophorinae

ABSTRACT - We sampled *Inga* Busk species caterpillars weekly in the cerrado on 15 plants of *Diospyros burchellii* Hern. (Ebenaceae) from January 2002 to December 2003, on 30 plants of *Caryocar brasiliense* (Caryocaraceae) from July 2003 to June 2004, and since 1991 on several other plant species. In total we found 15 species of *Inga* on cerrado host plants. Nine species were very rare, with only one to five adults reared. The other six species occurred throughout the year, with higher abundance during the dry season, from May to July, coinciding with overall peaks of caterpillar abundance in the cerrado. Caterpillars of the genus *Inga* build shelters by tying and lining two mature or old leaves with silk and frass, where they rest and develop (a common habit found in Oecophorinae). The final instar builds a special envelope inside the leaf shelter, where it will complete the larval stage and pupate. The species are very difficult to distinguish in the immature stages. External features were useful in identifying only four species: *I. haemataula* (Meyrick), *I. phaecrossa* (Meyrick), *I. ancorata* (Walsingham), and *I. corystes* (Meyrick). These four species are polyphagous and have wide geographical distributions. In this paper we provide information on the natural history and host plants of six *Inga* species common on cerrado host plants, for which there are no reports in the literature.

KEY WORDS: *Caryocar*, diet, *Diospyros*, leaf shelter, Oecophorinae

Except for species considered as pests in cultivated areas, very little is known of the immature stages of tropical Lepidoptera and their host plants in natural environments, especially for micromoths. Most knowledge is discontinuous and deals particularly with butterflies and macromoths (e.g. Brown & Freitas 1994, Furtado & Lemaire 1999, Morais & Diniz 2003).

The Oecophoridae are widely distributed in Australia where their caterpillars specialize in eating fallen *Eucalyptus* leaves (Gullan & Cranston 2005), and are common also

throughout North America. Most Oecophoridae are of little or no economic importance; however, a few Oecophorinae can be serious pests throughout the world (Costa-Lima 1945, Stehr 1987). Despite the high species richness of Australian Oecophoridae the genus *Inga* Busk (Oecophorinae, Oecophorini) is predominantly Neotropical, with few species occurring in Neartic regions (Hodges 1972).

Heppner (1984) published a list of 98 *Inga* species, which, together with their synominies, comprised 110 names. Of these, 94 were first collected in South America, 28 at type localities in Brazil, especially in the Amazon Region (states of Amazonas and Pará) and in the states of São Paulo, Rio de Janeiro and Pernambuco. The only other information about the genus *Inga* in Brazil concerns the occurrence of *I. crossota* (Walsingham) (= *Machimia crossota*) whose caterpillar eats mango leaves (Ribeiro 1951).

Caterpillars of three large and diverse moth families, Oecophoridae, Gelechiidae and Cosmopterigidae, present very similar morphologies (Stehr 1987). These similarities are encountered amongst *Inga* caterpillars. It is very difficult to separate the species using characters of the caterpillars, and it is necessary in most cases to rear them to adults for identification. Additional studies that include caterpillar diagnosis are needed to provide more accuracy in species identification of immatures.

The present study provides data on biological and ecological aspects of *Inga* species on cerrado host plants in Brazil, especially on *Diospyros burchelli* Hern (Ebenaceae) and *Caryocar brasiliense* Camb. (Caryocaraceae). Our studies of these micro-moth caterpillars had three primary objectives: i) to describe morphological traits and behavior of the caterpillars of different species; ii) to determine their diet breadth on the cerrado vegetation; and iii) to compare the variation of this fauna on two taxonomically unrelated host plants.

Material and Methods

The data presented here were obtained from (a) previous surveys of *Inga* caterpillars on several cerrado host plant species, since 1991 (Diniz *et al.* 2001), and (b) specific surveys of *Inga* caterpillars carried out by us on *D. burchelli* from January 2002 to December 2003, and on *C. brasiliense* from July 2003 to June 2004.

D. burchelli is a deciduous plant, common in the cerrado vegetation, which looses and replaces leaves during the transition from dry to wet seasons (September-October), and is pubescence on both surfaces of new leaves. *C. brasiliense* is a tree, also very common in the cerrado, which reaches about 6 m in height, loosing and flushing its leaves at the end of the dry season (August-September), and producing pubescent new leaves.

The fieldwork was carried out in an area of cerrado *sensu stricto* (Oliveira-Filho & Ratter 2002), at the Fazenda Água Limpa (FAL), experimental farm of the Universidade de Brasilia (15° 56'S, 47° 54'W), near Brasilia in the Federal District, Brazil.

Fifteen plants of *D. burchelli* and 30 of *C. brasiliense* were examined weekly for caterpillars. All *Inga* caterpillars were collected, brought to the laboratory, and reared in plastic cages until adult emergence. To maintain the swelling turgidity of the leaves, the petioles were immersed in moist cotton, and fresh leaves were supplied to the caterpillars every two days. Behavioral and developmental aspects, such as the construction of shelters and the duration of the pupal stage, were observed in the field and under laboratory conditions. All data presented here were based on adult emergence in the laboratory.

Vitor O. Becker identified the moth species, and voucher specimens were deposited in the Entomological Collection of the Zoology Department of the University of Brasilia.

Results

The caterpillars of 15 species of *Inga* were reared to adults (n = 388) (Fig. 1). These species were found and reared on 36 host species representing 21 plant families. However, only six species were identified to species level. These species showed wide geographical distribution based on each type localities: *I. ancorata* (Walsingham) from Costa Rica, *I. corystes* (Meyrick) from Guyana, *I. encamina* (Meyrick) from Venezuela, *I. erythema* (Walsingham) from Guatemala, *I. haemataula* (Meyrick,) from São Paulo, Brazil, and, *I. phaeocrossa* (Meyrick) from Rio de Janeiro, Brazil (Heppner 1984) (Table 1).

Inga phaeocrossa and *I. haemataula* were the most abundant species on the majority of plant species surveyed, and the type localities of both species are Brazil (Heppner 1984). Nine species were very rare, with only one to five adults reared (Table 1). Of the six species with more than 10 adults reared, five were polyphagous, and the other (sp. # 14) had been found, up to now, only on *Davilla elliptica* St.Hil. (Dilleniaceae). Though *I. ancorata* was found on three host plants, it showed a strong preference for *C. brasiliense* as evidenced by the fact that only three individuals out of 69 were encountered on other plants. Two plant species *D. burchellii* and *Qualea parviflora* Mart. (Vochysiaceae) supported the highest richness of *Inga* species (seven species).

We surveyed 1,464 plants of *D. burchellii* and found 419 caterpillars, 83 of which belonged to the genus *Inga*. We reared 56 caterpillars to adults representing seven species of *Inga*, of which *I. haemataula* was the most abundant, accounting for 75% of all *Inga* fauna of *D. burchellii* (Table 1). The caterpillars of *Inga* on *D. burchellii* were present from January to August, being most frequent from May to July, which coincides with the first half of the dry season in the cerrado (Fig. 2). None of the *Inga* caterpillars on *D. burchellii* (n = 83) suffered from parasitoid attacks.

We surveyed 1,250 plants of *C. brasiliense* and found 570 caterpillars of which 88 belonged to *Inga* species. Four species of *Inga* were represented, of which *I. ancorata* was the most abundant, accounting for 75% of the *Inga* fauna on *C. brasiliense* (Table 1). *Inga* caterpillars on *C. brasiliense* were present all year, except in September and October, and were most frequent from May to July, which is the first half of the dry season in the cerrado (Fig.2). Five (9%) caterpillars of *I. ancorata* were parasitized by Hymenoptera.

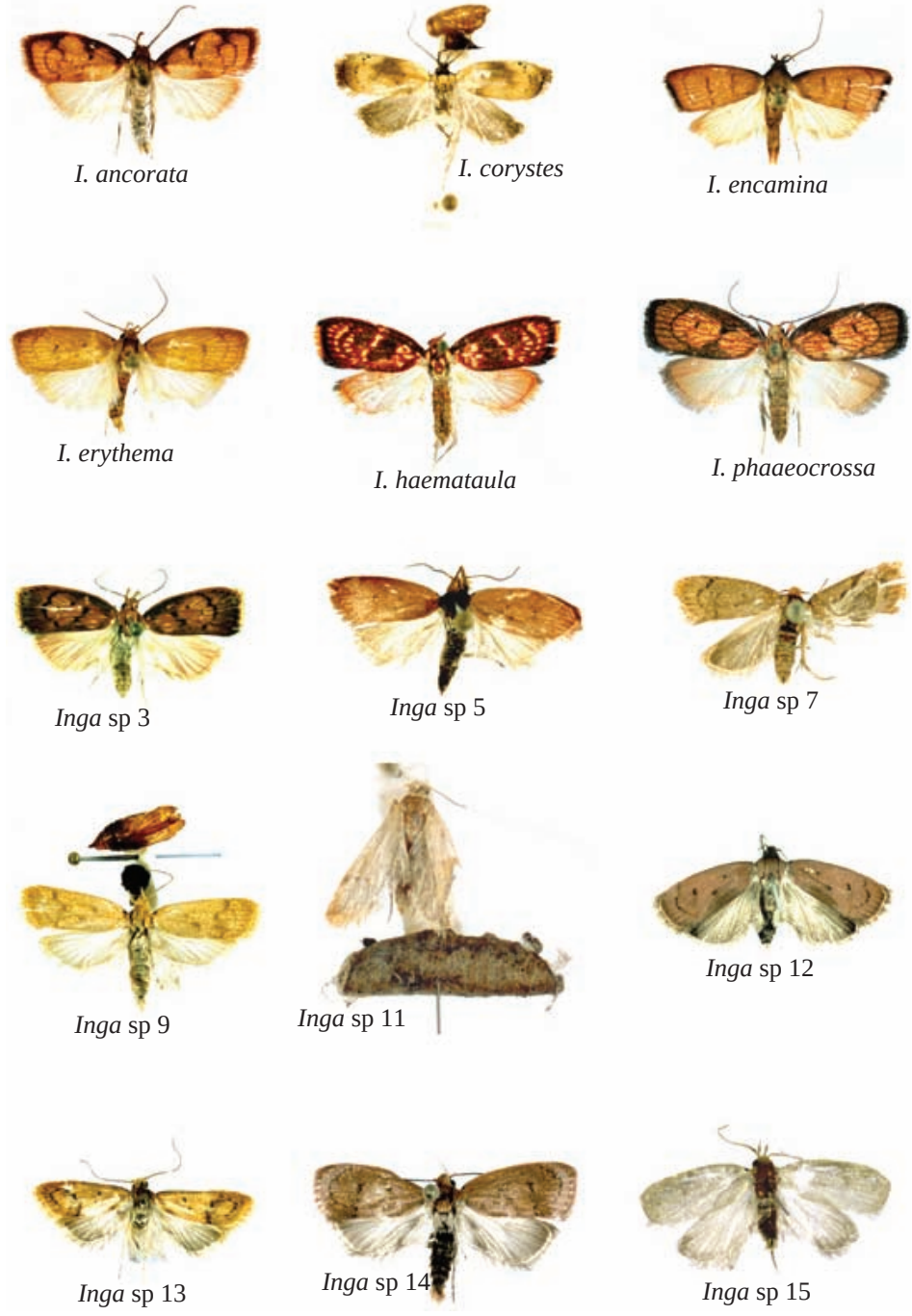

Fig. 1. Adults of fifteen species of *Inga* found on cerrado hostplants in Federal District.

The early-instars of all species build their shelters, opened at the extremities, by binding two mature or senescent leaves together with silk, and lining them with a layer of frass interwined with silk threads, where, they feed and use it as a resting place. As the larvae mature they begin to forage outside the leaf shelter. Caterpillars reacted to any disturbance outside the shelter by wiggling off the leaf and suspending themselves by silken threads. Later instars cut spheres of about 3 cm in diameter and build an envelope-like structure big enough to fit inside the leaf shelter. All *Inga* species pupated inside the envelopes on the same host plant where they lived and fed as caterpillars.

In the laboratory, the pupal duration of *I. haemataula* was an average of 27.7 days ± 5.4 (n = 10), noticeably longer than that of *I. ancorata* (18.3 days ± 8.3, n = 66), *I. phaeocrossa* (20 days ± 2.3, n = 7), or *I. encamina* (15 days ± 2.9, n = 11), and pupal duration varied enormously within each species, even when reared on the same host plant. In *I. ancorata*,

Table 1. Species of *Inga* found in cerrado areas in Federal District in Brazil, number of host plant species, number of adults obtained on *C. brasiliense*, *D. burchelli* and other plant species, and total number of adults reared. The *Inga* morphospecies numbers refer to our specimens in our collection.

Inga species	Nº. of host plant species	Nº. on *C. brasiliense*	Nº. on *D. burchelli*	Nº. on other plant species	Total of adults
I. ancorata (Walsingham)	3	66		3	69
I. corystes (Meyrick)	1		3		3
I. encamina (Meyrick)	8	11	1	15	27
I. erythema (Walsingham)	1			1	1
I. haemataula (Meyrick)	21	10	42	53	105
I. phaeocrossa (Meyrick)	24	1	7	122	130
Inga sp. 3	6		1	22	23
Inga sp. 5	3		1	3	4
Inga sp. 7	1			1	1
Inga sp. 9	2			2	2
Inga sp. 11	1			1	1
Inga sp. 12	2			2	2
Inga sp. 13	2			5	5
Inga sp. 14	1			14	14
Inga sp. 15	1		1		1

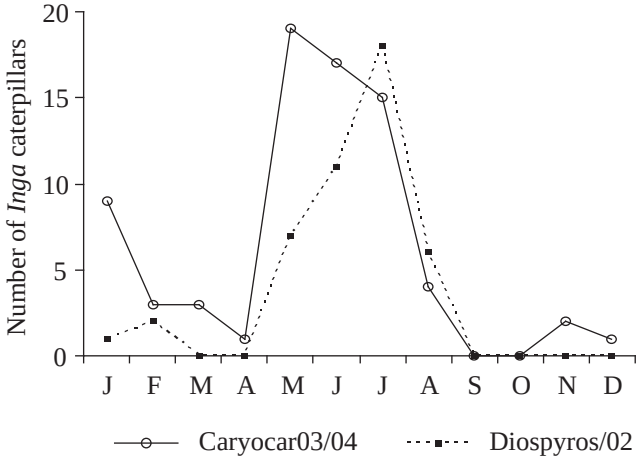

Fig. 2. Number of *Inga* caterpillars found on *D. burchellii* in 2002 and on *C. brasiliensis* in 2003/2004.

for example, the minimum duration was seven days and the maximum was 74 days (n = 66).

The immature stages of some *Inga* species are extremely difficult to distinguish using morphological features. Two species, *I. ancorata* (Fig. 3a) and *I. corystes*, have pale green tegument but can be distinguished by the color of the head, which is pale green in the former and shiny black in the latter. *Inga* sp. 5 and *Inga* sp. 15 are similar to *I. corystes*, and no particular feature was found to distinguish among these three species.

Other species such us *I. phaeocrossa*, *I. haemataula*, and *I. encamina* are much more difficult to distinguish without careful observation of their features under high magnification. *Inga haemataula* has the head and prothothoracic shield reddish chestnut color, body paler than head and prothothoracic shield, with longitudinal pale brownish stripes with spots of the same color between them; mesothoracic segment with two black pinacula surrounded by a pale yellow circle; metathoracic segment pale yellow with chestnut-color stripes; prolegs each with a bright orange spot (Fig. 3b). *I. encamina* is similar to *I. haemataula* except that the head is reddish brown and lacks the two black pinacula. *Inga* sp.3 is similar to *I. haemataula*, and no particular feature was found to distinguish the caterpillars of these two species. *Inga phaeocrossa* (Fig.3c) colored and patterned as *I. haemataula*, but with pale brownish head and tegument, and the body with brownish stripes paler and less well defined than those of *I. haemataula*, and the prolegs lacking the orange spots.

Discussion

Inga abundance increases sharply from April to July (the peak) during the first half of the dry season, matching the general peak of caterpillar abundance in the cerrado (Morais *et al*. 1999). Larvae of all species of *Inga* were found mainly on mature leaves that were reaching senescence or even dry. That wasn't surprising because most members of the Oecophorinae eat dead plant material, and rarely eat live plants (Hodges 1972, Gullan & Cranston 2005).

Young leaves of *D. burchellii* have high concentrations of trichomes on both surfaces. Caterpillar preference for mature or senescent leaves could be due to the low density of trichomes found on mature leaves of this plant, or perhaps

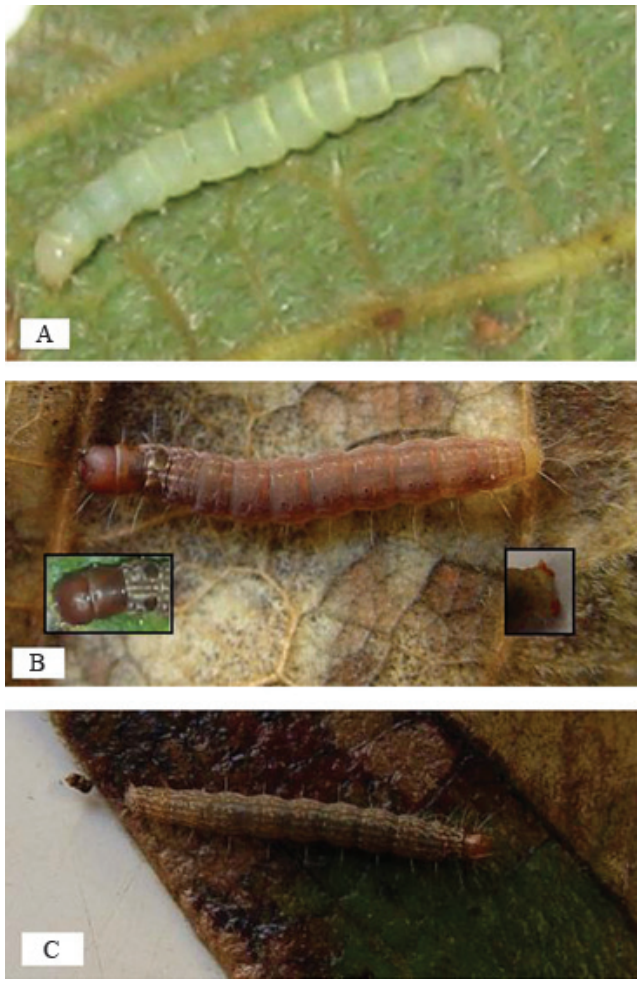

Fig. 3. Caterpillars of three species of *Inga* showing morphological differences among: a) *I. ancorata*; b) *I. haemataula* showing the two black pinacula and the bright orange spot on the prolegs; c) *I. phaeocrossa*.

reflects lower concentrations of protective chemicals. *D. burchellii* leaves mature from March to August, coinciding with the highest abundance of *Inga* species on them. The total absence of any species of *Inga* from September to December corresponds to the falling of leaves or the recent flushes on this host plant.

Apart from *I. phaeocrossa*, *I. haemataula*, *I. corystes* and *I. encamina*, the immature stages of other species could not be identified precisely using external features. *I. haemataula* and *I. phaeocrossa* were the most abundant species, making it easier to find external features that would distinguish them from the others. Other species must be found in large enough numbers to permit specific identifying features of each species to be found. According to Vitor Becker (pers. com.), even the adults of many species belonging to this genus are unnamed and more studies are needed for their identification.

Leaf shelters are known to protect caterpillars from predators (Damman 1987, Ruehlmann *et al*. 1988, Loeffler 1996), to create favorable microclimates (Henson 1958, Larsson *et al*. 1997), and to increase the quality of the leaves on which they feed. (Sagers 1992, Costa & Varanda 2002). *Inga* shelters in the Brazilian cerrado are found during the driest season, and perhaps help caterpillars to avoid desiccation by creating a more humid microclimate. The shelters may help as well to avoid parasitoids, given that very few larvae were parasitized. Another explanation for the low proportion of parasitized larvae might be that dry season is the period of lowest parasitoid abundance in the cerrado, providing enemy free space (Morais *et al.* 1999).

Whereas pupation duration and shelter building of some species of *Inga* could be well observed under laboratory conditions, and the larvae of a few could be identified easily, experiments involving complete life cycles still need to be carried out to increase our understanding on biological aspects of all species of *Inga*. Also, very little information is available about the biology of the adults. Further studies are needed to determine whether individuals of polyphagous species lay their eggs on the same plant species that they developed on. This work provides the first set of ecological and biological information for the moth genus *Inga*. Although it is well recognized that most phytophagous insects tend to feed on more or less closely related host plants rather than on a random selection of plants from a local flora (Strong *et al*. 1984, Novotny *et al*. 2002), we have shown that in the cerrado *Inga* caterpillars feed on a wide variety of non-related host plant families including some isolated ones, such as Caryocaraceae and Proteaceae both of which are monotypic in this region. Our results are based on an extensive data set that showed a strong preference by *I. ancorata* for *C. brasiliense*, suggesting a change of host plant utilization by this species during its life cycle.

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