Pseudautomeris brasiliensis (Lepidoptera: Saturniidae) and *Stenoma* sp. (Lepidoptera: Elachistidae) Feeding on Crops of *Ctenanthe kummeriana* (Marantaceae) in Brazil and an Associate Parasitoid, *Enicospilus tenuigena* (Hymenoptera: Ichneumonidae)

Author(s): W. De S. Tavares , J. C. Legaspi , A. R. Lima , M. A. Soares , A. I. De A. Pereira , and J. C. Zanuncio

Source: Annals of the Entomological Society of America, 107(2):413-423. 2014.
Published By: Entomological Society of America
URL: http://www.bioone.org/doi/full/10.1603/AN13065

Pseudautomeris brasiliensis (Lepidoptera: Saturniidae) and *Stenoma* sp. (Lepidoptera: Elachistidae) Feeding on Crops of *Ctenanthe kummeriana* (Marantaceae) in Brazil and an Associate Parasitoid, *Enicospilus tenuigena* (Hymenoptera: Ichneumonidae)

W. DE S. TAVARES,[1,2] J. C. LEGASPI,[3] A. R. LIMA,[4] M. A. SOARES,[5] A. I. DE A. PEREIRA,[6] AND J. C. ZANUNCIO[7]

Ann. Entomol. Soc. Am. 107(2): 413–423 (2014); DOI: http://dx.doi.org/10.1603/AN13065

ABSTRACT *Ctenanthe kummeriana* (E. Morren) Eichler (Marantaceae) is a cosmopolitan ornamental plant with esthetically appealing color and leaf shape. *Pseudautomeris brasiliensis* Walker (Lepidoptera: Saturniidae) and a nondescribed species of *Stenoma* (Lepidoptera: Elachistidae) defoliated this plant in the campus of the Federal University of Viçosa (UFV), Viçosa, Minas Gerais State, Brazil, inspiring the study of the association that prevails among these organisms. This could be a rare event, as the association of Lepidoptera with Marantaceae is scarce, with only two previous reports. The aim of this study was to monitor the caterpillars on the two crops of *C. kummeriana*, one in the "Horto Botânico" (HB) and another in the "Recanto da Cigarra" (RC) for a period of 1 yr, with particular attention to the shelters and damage caused; to assess the gregarious nature and the emergence of parasitoid and lepidopterans; and to provide an accurate morphologic diagnosis of a parasitoid. *P. brasiliensis* and *Stenoma* sp. were recorded after the rainy season, exhibiting similar distribution between HB and RC. *Enicospilus tenuigena* Kriechbaumer, 1901 (Hymenoptera: Ichneumonidae) emerged from 76.25% of the *P. brasiliensis* pupae. *P. brasiliensis* and *Stenoma* sp. defoliated the *C. kummeriana* plants between March and June in the UFV campus, whereas the parasitoid *E. tenuigena* reduced the populations of the first species.

KEY WORDS damage, emergence, monitoring, Ophioninae, Zingiberalis

Ornamental plants native to the Atlantic Rainforest biome, Brazil, are cultivated for landscaping purposes in the campus of the Federal University of Viçosa (UFV), Viçosa, Minas Gerais State, Brazil, where they are commonly defoliated by lepidopterans. In turn, these herbivores are parasitized in situ mainly by Hymenoptera (Tavares et al. 2011c,d; 2012b), and also have been successfully used as alternative hosts for laboratory rearing of parasitoids of agricultural and forest pests (Tavares et al. 2011b, 2012a, 2013a).

Ctenanthe kummeriana (E. Morren) Eichler (Marantaceae) is cultivated in the UFV campus. This plant rarely occurs in the native forests of Brazil, but it is a common ornamental plant in this country and in Europe, where it was introduced in the 18th century (Abdullah et al. 2008). It is an herbaceous and perennial plant that is well adapted to humid tropical habitats. At a height of 0.6 m, with leaves opposite and lanceolate along the entire margin, the adaxial leaf surface shows characteristic green with white stripes, while the abaxial surface is purple. Tubular flowers appear at the tips (de Lima and Moura 2008).

Pseudautomeris brasiliensis Walker (Lepidoptera: Saturniidae) and others species of this genus have medicinal importance because of the human accidents when in contact on bristles of caterpillars, which can inoculate urticating substances and cause bleeding in allergic individuals (Veiga et al. 2001). Saturniidae adults are robust and scaly bodied, and some species can cause respiratory allergies in humans (Pereira et al. 2009b,c). The forewings of *P. brasiliensis* resemble dry leaves, whereas the hind wings have a circular ocellus. These nocturnal moths rest on dry leaves on the ground during the day, thereby camouflaging their forewings; however, when disturbed, they expose their hind wings revealing the ocelli and arching the abdomen presenting the visual image of a bird beak (W.deS.T., unpublished data). *P. brasiliensis* occur in

[1] Departamento de Fitotecnia, Universidade Federal de Viçosa, 36570-000 Viçosa, Minas Gerais State, Brazil.
[2] Corresponding author, e-mail: wagner.tavares@ufv.br.
[3] United States Department of Agriculture - Agricultural Research Service, CMAVE/Florida A&M University - Center for Biological Control, 6383 Mahan Dr., Tallahassee, FL 32308.
[4] Pós-Graduação em Zoologia, Departamento de Zoologia, Universidade Federal de Minas Gerais, 31270-901 Belo Horizonte, Minas Gerais State, Brazil.
[5] Departamento de Agronomia, Universidade Federal dos Vales do Jequitinhonha e Mucuri, 39100-000 Diamantina, Minas Gerais State, Brazil.
[6] Departamento de Agronomia, Instituto Federal Goiano, 75790-000 Urutaí, Goiás State, Brazil.
[7] Departamento de Biologia Animal, Universidade Federal de Viçosa, 36570-000 Viçosa, Minas Gerais State, Brazil.

Alagoas, Bahia, Espírito Santo, Goiás, Pernambuco, Rio de Janeiro, and Santa Catarina States of Brazil (Lemaire 2002).

Sixteen species of *Stenoma* (Lepidoptera: Elachistidae) and their hosts have been reported in Brazil. *Stenoma deltopis* Meyrick, 1915 feed on unknown host; *Stenoma phalocropa* Meyrick, 1932, *Stenoma salome* Busck, 1911, and *Stenoma* spp. (10 nondescribed species) feed on *Byrsonima coccolobifolia* (Spreng.) Kunth (Malpighiaceae); and *Stenoma cathosiota* Meyrick, 1925 feed on *Roupala montana* Aubl. (Proteaceae), all occurring in the Cerrado biome, Brasília (Morais et al. 2007, Diniz et al. 2011). In São Paulo State Cerrado, *Stenoma scitiorella* Walker, 1864 defoliates *Xylopia aromatica* (Lam) Mart. (Annonaceae) (Varanda et al. 2008). *Stenoma catenifer* Walsingham, 1912 feeds on *Nectandra megapotamica* Mez and *Cinnamomum camphora* L. (Lauraceae) in the Minas Gerais and Rio Grande do Sul States (Nava et al. 2005, 2006; Link and Link 2008).

Enicospilus tenuigena Kriechbaumer, 1901 (Hymenoptera: Ichneumonidae) is found in Brazil, Colombia, Costa Rica, Ecuador, and Panama (Gauld 1988). The taxonomic key to some of the Neotropical species of this genus has been provided (Lima et al. 2012). Parasitism by members of this genus was reported among the economically important Lepidoptera in Africa, Asia, and Europe. In Turkey, *Enicospilus ramidulus* L., 1758 parasitized *Hyphantria cunea* Drury, 1773 (Lepidoptera: Arctiidae), which feed on *Corylus avellana* L. (Betulaceae) (Sullivan et al. 2010). In Kenya, *Enicospilus antefurcalis* Szépligeti, 1908 and *Enicospilus ruscus* Gauld & Mitchell, 1978 parasitized *Sesame* sp. (Lepidoptera: Pyralidae) on *Cyperus papyrus* L. (Cyperaceae) and *Setaria megaphylla* (Steud) Dur. & Schinz (Poaceae), respectively, and *Busseola* sp. (Lepidoptera: Noctuidae) parasitized on *S. megaphylla* (Mailafiya et al. 2009). In India, *Enicospilus* sp. parasitized *Mythimna separata* Walker, 1865 (Lepidoptera: Noctuidae) on *Sorghum* spp. and *Pennisetum* spp. (Poaceae) (Sharma et al. 2002).

P. brasiliensis and *Stenoma* sp. feeding on *C. kummeriana* could be a rare event, as the association of Lepidoptera with Marantaceae is scarce, with only two previous reports (Murray 2001, Bauder et al. 2011). The number of noncultivated host plants of species of Elachistidae and Saturniidae is poorly known, though those with agricultural and forest importance have been studied more extensively (Pereira et al. 2008, 2009a). The aim of the current study was to monitor the caterpillars in two crops of *C. kummeriana* in the UFV campus for a period of 1 yr, with particular focus on the characteristic to the shelters and damage caused, the gregarious nature and emergence of parasitoid and lepidopterans, and to provide an accurate morphologic diagnosis of a parasitoid.

Materials and Methods

Characterization Site. The study was conducted at the UFV campus in two crops of *C. kummeriana*, in the "Horto Botânico" (HB; Fig. 1A; 20° 45′ S, 42° 51′ W, 651 m above sea level) and in the "Recanto da Cigarra" (RC; Fig. 1B; 20° 45′ S, 42° 53′ W, 655 m above sea level).

Quadrant Sampling. Caterpillars were monitored every 14 d for a period of 1 yr (June 2011 to June 2012) on HB and RC. Five quarters of a square meter each were randomly marked with string and sampled by crop. The number of caterpillars was counted per quadrant, except the insects on the plants, using a modified methodology proposed to sample *S. catenifer* in groves of *Persea americana* Mill. (Lauraceae) in the Neotropical region (Nava et al. 2006). The leaves and shelters were surveyed in the quadrants and the caterpillars found were counted. The *P. brasiliensis* caterpillars were monitored on the leaves they were feeding on, while those of *Stenoma* sp. were monitored on the leaf shelters. Only shelters that contained at least one caterpillar of *Stenoma* sp. were sampled. A piece of organza (35 by 35 cm) was lined on the ground, below the shelters, to help count the number of fallen caterpillars and to place the caterpillars back within their respective shelters.

Shelters, Gregariousness, and Ecological Characteristics. The number of leaves used (one, two, three, or four) in the construction per shelter and the number of last-instar *Stenoma* sp. caterpillars in each group were assessed per quadrant. The ecological characteristics of *P. brasiliensis* and those of *Stenoma* sp. on *C. kummeriana* were described (egg-laying behavior, habit, parts consumed, injuries, shelters, cocoons, pupation, and postinjury effect).

Emergence of the Parasitoid. Ten last-instar caterpillars of each *P. brasiliensis* and *Stenoma* sp., were collected in each year of this study, on 15 and 30 June. They were placed in rearing cages (30 by 30 by 30 cm) in the Laboratory of Biological Control of Insects (LCBI) at UFV. These caterpillars were fed ad libitum with leaves of their respective hosts until pupation. The pupae were kept in 500-ml plastic pots until the emergence of lepidopterans or parasitoid. The *P. brasiliensis* caterpillars were collected from leaves and those of *Stenoma* sp. from the shelters per quadrant. The emergence (%) of *E. tenuigena* from the *P. brasiliensis* pupae was evaluated.

Emergence of the Lepidopterans and Unviable Pupae. The percentage of pupae with the emergence of *P. brasiliensis* and *Stenoma* sp. and the unviable pupae of the latter species were evaluated.

Morphological Diagnosis. A accurate morphological diagnosis of the parasitoid *E. tenuigena* was provided, including forewing measurements (mm) and color pattern.

Statistical Analysis. Designed in randomized blocks, the data were subjected to the Burr–Foster Q and Shapiro–Wilk W tests to assess the equality of variance and normality (Anderson and McLean 1974). Transformations were applied when necessary (Ostle and Mensing 1975). The monitoring period of caterpillars was the source of variation of the variance analysis (ANOVA) and the means were compared using the Scott–Knott test at 5% probability with the program Sistema para Análises Estatísticas (SAEG) (2007).

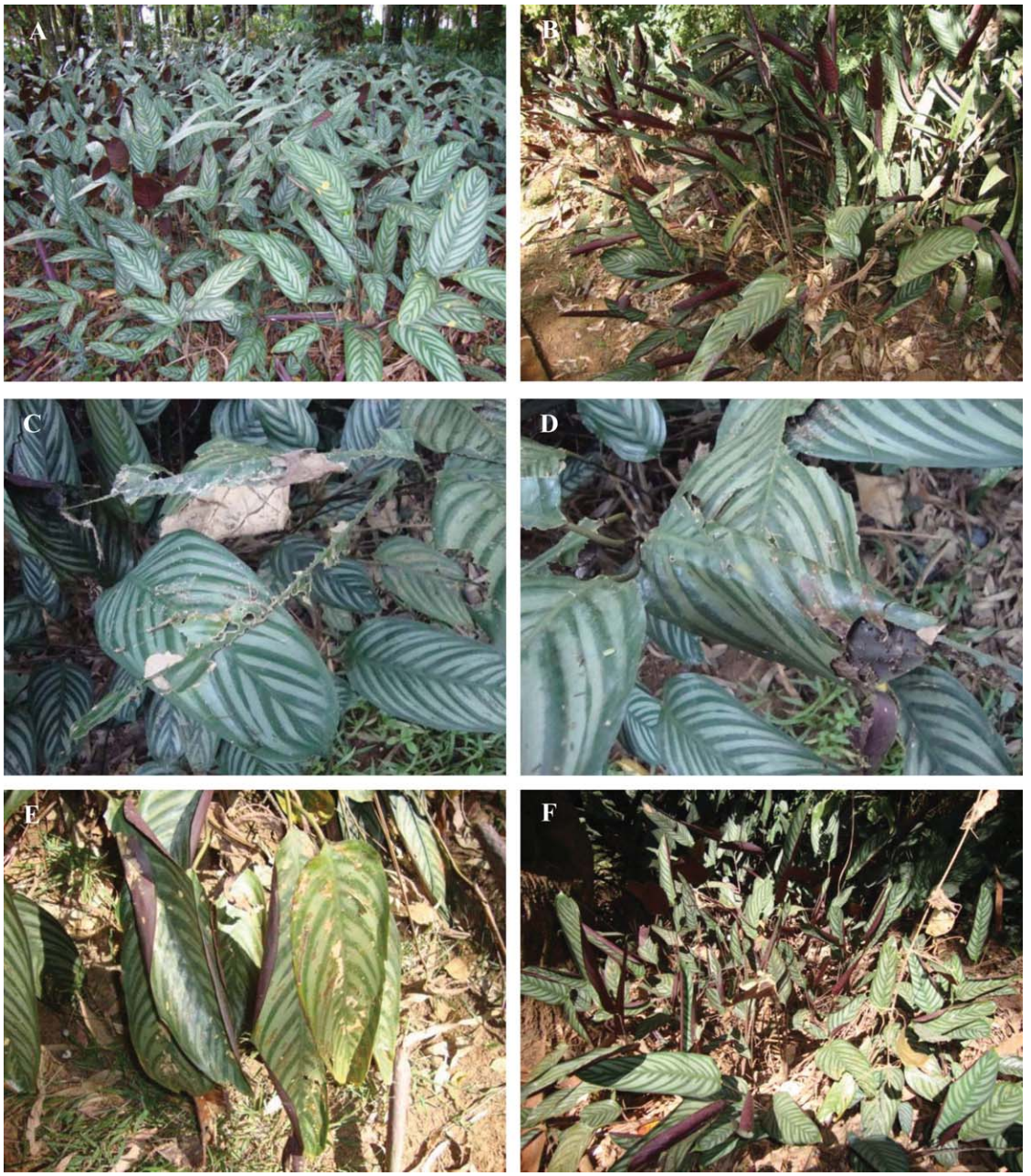

Fig. 1. Crops of *Ctenanthe kummeriana* (Marantaceae), in the "Horto Botânico" (HB – A) as well as in the "Recanto da Cigarra" (RC – B), in the *campus* of the Federal University of Viçosa in Viçosa, Minas Gerais State, Brazil, during and after 30 d (C–D in the HB × E–F in the RC) of attack by *P. brasiliensis* (Lepidoptera: Saturniidae) and *Stenoma* sp. (Lepidoptera: Elachistidae). (Online figure in color.)

Identification and Deposit of Material. The moths and the parasitoids that emerged, as well as the host plant, were identified. *P. brasiliensis* was identified by Dr. Olaf Hermann Hendrik Mielke and deposited at the Federal University of Paraná, Curitiba, Paraná State, Brazil. *Stenoma* was identified as a nondescribed species by Dr. Vitor Osmar Becker and deposited in the Uiraçu Institute in Camacan, Bahia State, Brazil. *E. tenuigena* was identified by the third author and deposited at the Federal University of Minas Gerais. *C. kummeriana* was identified by Dr. João Marcelo Alvarenga Braga (Botanical Garden Research Institute of Rio de Janeiro, Rio de Janeiro State, Brazil). Samples from these insects and a dried pressed sample, and two duplicates of this plant were deposited in the entomological collection and herbarium of the UFV, respectively.

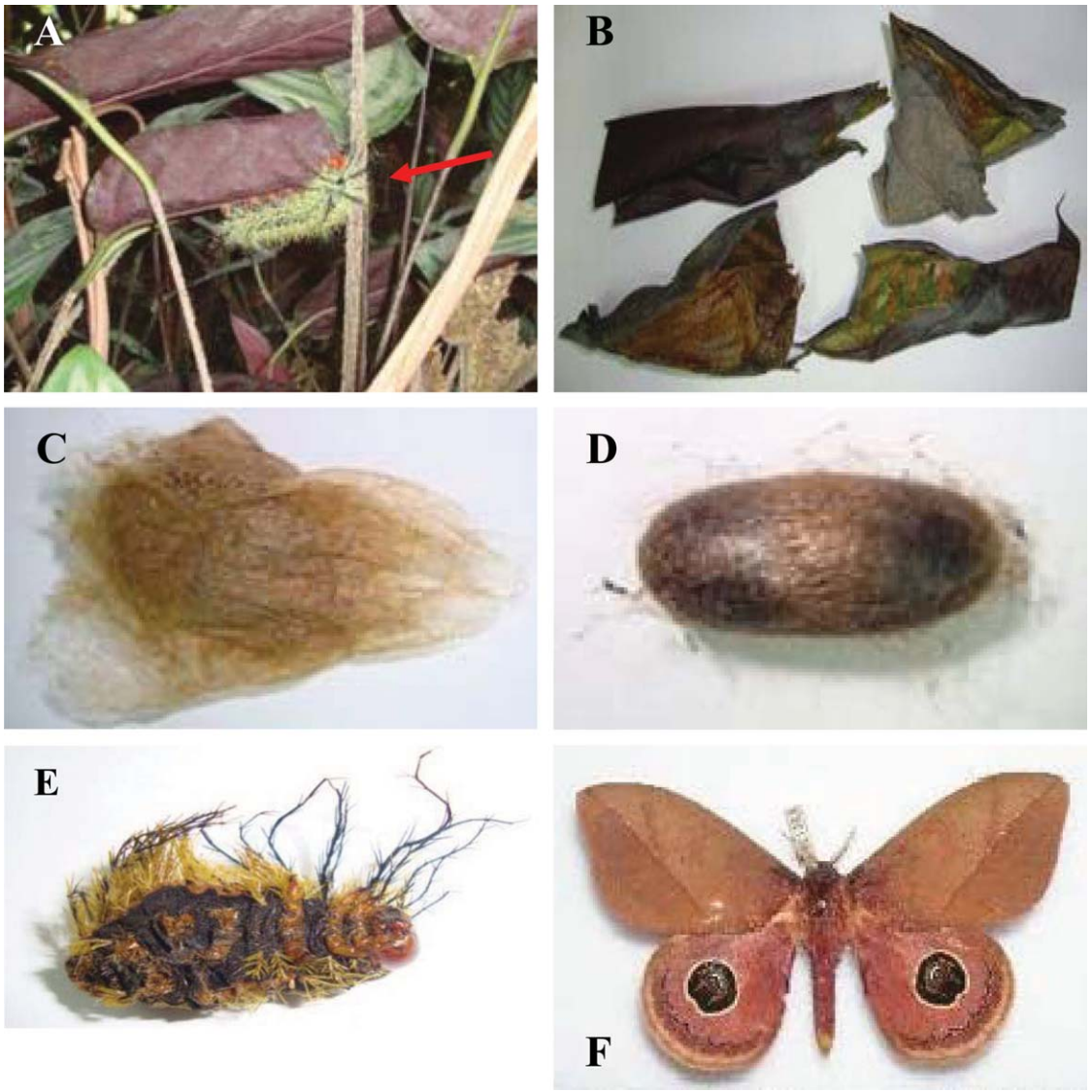

Fig. 2. Last-instar caterpillar of *P. brasiliensis* (Lepidoptera: Saturniidae) (A), cocoon wrapped by a *Ctenanthe kummeriana* (Marantaceae) leaf and silk threads (B) or, silk threads alone (C), cocoon involving pupa (D), exsuviae (E), and adult (F). (Online figure in color.)

Results

Host and Occurrence of Caterpillars. This is the first evidence of *C. kummeriana* as a host of *P. brasiliensis* (Fig. 2A–F) and *Stenoma* sp. (Fig. 3A–E). The crops of *C. kummeriana* (HB and RC) are in a shaded area of the UFV campus, contributing to the maintenance of moisture through June, when the soil may become dry because of lack of precipitation (low relative humidity).

The number of caterpillars per species and quadrant was similar among the samples and crops (HB and RC; Table 1). First-instar caterpillars of both species were observed in March and April (the rainy season with high temperature), middle instar in May (intermediate rainfall and temperature period), and last instar in June (dry season). The data suggest one generation per year for *P. brasiliensis* and *Stenoma* sp. on *C. kummeriana* in Brazil.

Egg-Laying Behavior, Damage, Pupation, and Habit of *P. brasiliensis*. *P. brasiliensis* lays its eggs in the adaxial and abaxial surfaces of the *C. kummeriana* leaves with one egg mass per leaf. The *P. brasiliensis* caterpillars fix themselves on the side of the *C. kummeriana* leaves, where they feed, leaving the midrib intact. However, the leaves are not fully consumed, because these caterpillars constantly migrate. Pupation occurs on the host leaves, within a dark brown cocoon, protected by a shelter constructed with

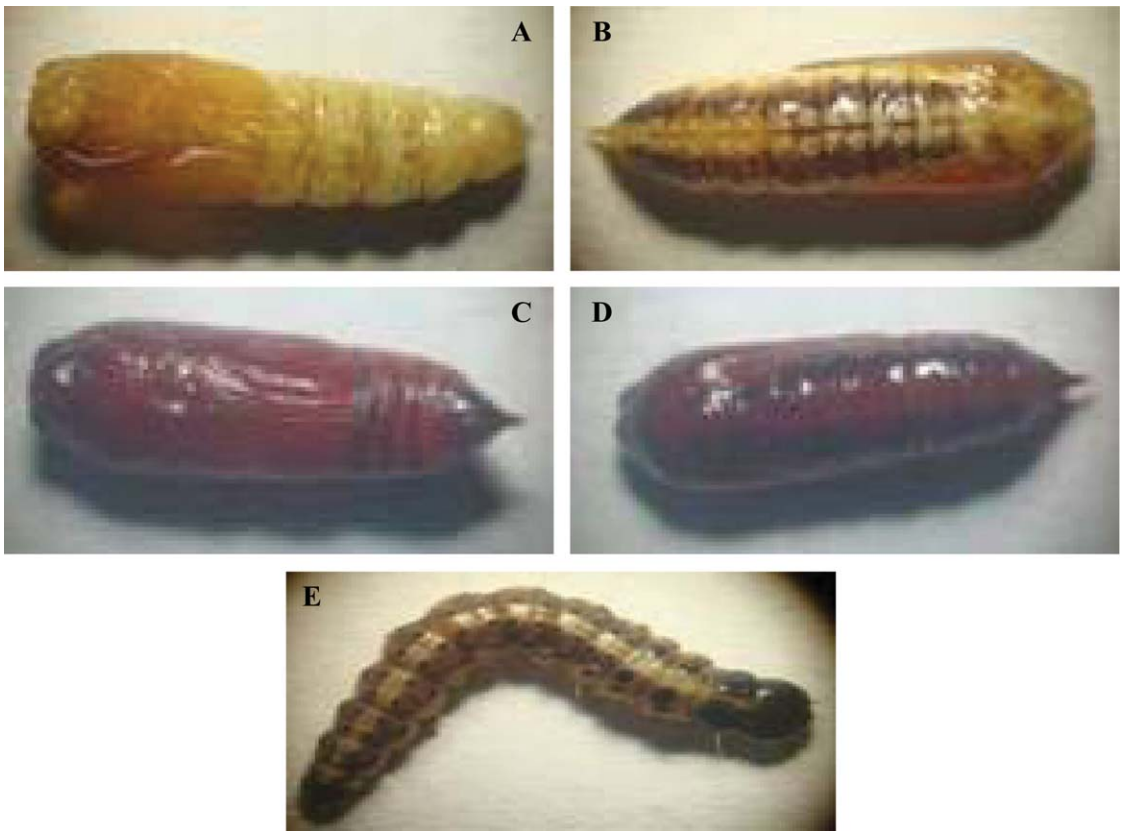

Fig. 3. Prepupa (front view – A, and top view – B), pupa (front view – C, and top view – D) and last-instar caterpillar of *Stenoma* sp. (Lepidoptera: Elachistidae) (E). (Online figure in color.)

folded sheets and silk beige synthesized by the caterpillar (Fig. 2A–E) or, alternatively, on other plant species up to 40 m away from the crop edge. The caterpillars were gregarious during the initial weeks of life and solitary toward the end of development.

Egg-Laying Behavior, Damage, Pupation, and Habit of *Stenoma* sp. *Stenoma* sp. lays its eggs on the adaxial surface of the leaves of *C. kummeriana.* One egg mass was observed per leaf. Immediately after hatching caterpillars begin constructing shelters to feed and

Table 1. Number (mean ± SE) of *P. brasiliensis* (Lepidoptera: Saturniidae) and *Stenoma* sp. (Lepidoptera: Elachistidae) caterpillars per quadrant in the two crops of *C. kummeriana* (Marantaceae), in HB and RC, in the campus of the UFV, Minas Gerais State, Brazil

Sampling date	*P. brasiliensis*			*Stenoma* sp.		
	HB	RC	Mean	HB	RC	Mean
15 June 2011	8.4 ± 3	7.6 ± 3	8.0 ± 3	58.7 ± 21	55.4 ± 23	57.0 ± 22
30 June 2011	6.5 ± 2	6.3 ± 2	6.4 ± 2	55.8 ± 23	54.1 ± 23	54.9 ± 23
Mean	7.4 ± 2	6.9 ± 2	7.2 ± 2	57.2 ± 22	54.7 ± 23	55.9 ± 22
15 Mar. 2012	32.1 ± 14	30.9 ± 17	31.5 ± 15	103.2 ± 54	99.8 ± 54	101.5 ± 54
31 Mar. 2012	34.1 ± 14	31.3 ± 13	32.7 ± 13	100.7 ± 52	99.2 ± 51	99.9 ± 51
Mean	33.1 ± 14	31.1 ± 15	32.1 ± 14	101.9 ± 53	99.5 ± 52	100.7 ± 52
15 April 2012	23.6 ± 9	25.4 ± 8	24.5 ± 8	84.7 ± 42	82.4 ± 45	83.5 ± 43
30 April 2012	21.0 ± 8	24.5 ± 8	22.7 ± 8	83.5 ± 41	83.8 ± 39	83.6 ± 40
Mean	22.3 ± 8	24.9 ± 8	23.6 ± 8	84.1 ± 41	83.1 ± 42	83.5 ± 41
15 May 2012	15.9 ± 5	17.7 ± 5	16.8 ± 5	69.1 ± 31	66.8 ± 32	67.9 ± 31
31 May 2012	15.6 ± 6	16.2 ± 6	15.9 ± 6	67.5 ± 31	65.2 ± 29	66.3 ± 30
Mean	15.7 ± 5	16.9 ± 5	16.3 ± 5	68.3 ± 31	66.0 ± 30	67.1 ± 31
15 June 2012	7.5 ± 3	9.0 ± 3	8.2 ± 3	52.6 ± 19	49.9 ± 17	51.2 ± 18
30 June 2012	6.8 ± 2	7.2 ± 3	7.0 ± 2	51.2 ± 19	49.6 ± 19	50.4 ± 19
Mean	7.1 ± 2	8.1 ± 3	7.6 ± 2	51.9 ± 19	49.7 ± 18	50.8 ± 18

Means per sampling month in the columns and lines, per species, do not differ by the Scott–Knott test at 5% probability. Caterpillars of early instars were observed in March and April, those of intermediate instars in May, and those of last instar in June.

Fig. 4. Shelters with five (A) and 11 last-instar caterpillars of *Stenoma* sp. (Lepidoptera: Elachistidae) (B) constructed with two overlapping leaves (C) or a sheet in conical shelter of *Ctenanthe kummeriana* (Marantaceae) (D) and prepupae fixed by white silk threads (E). (Online figure in color.)

protect themselves. No caterpillars were found outside the shelters. Caterpillars feed on leaves, leaving only the midrib intact. The defoliation begins either at the tip or base of leaves, moving toward middle. The caterpillars synthesize and use white silk threads to attach one to four leaves, staying sheltered within the spaces. The caterpillars feed on fixed leaves and remain within the same shelter during their life cycle. Single leaf shelters are conical, whereas others have overlapping leaves. The caterpillars are gregarious during the development period. Groups of 5–11 last-instar caterpillars were observed per shelter, and different-instar caterpillars were not found within the same shelter. Pupation occurred within the spaces of the shelters (Fig. 4A–E). Plants injured by both defoliators turned yellow 30 d after the attack, lost their luster and showed curled leaves, though they did not die (Fig. 1C–F).

Shelters. The number of leaves used in shelter construction by the *Stenoma* sp. was similar among sam-

Table 2. Number (mean ± SE) of leaves per quadrant used by *Stenoma* sp. (Lepidoptera: Elachistidae) to build shelters on the two crops of *C. kummeriana* (Marantaceae), in the HB and RC, in the campus of the Federal University of Viçosa in Viçosa, Minas Gerais State, Brazil

Sampling date	HB	RB	Mean
15 June 2011	2.7 ± 0.9	2.8 ± 1.0	2.7 ± 0.9
30 June 2011	2.8 ± 0.9	2.6 ± 0.8	2.7 ± 1.0
Mean	2.7 ± 0.9	2.7 ± 0.9	2.7 ± 0.9
15 March 2012	1.7 ± 0.7	1.6 ± 0.6	1.6 ± 0.6
31 March 2012	2.0 ± 1.0	1.6 ± 0.6	1.8 ± 0.7
Mean	1.8 ± 0.8	1.6 ± 0.6	1.7 ± 0.6
15 April 2012	1.8 ± 0.8	1.9 ± 0.9	1.8 ± 0.7
30 April 2012	1.6 ± 0.6	1.7 ± 0.7	1.6 ± 0.6
Mean	1.7 ± 0.7	1.8 ± 0.8	1.7 ± 0.6
15 May 2012	2.1 ± 1.0	2.2 ± 1.2	2.1 ± 1.0
31 May 2012	2.3 ± 1.2	2.4 ± 1.2	2.3 ± 1.1
Mean	2.2 ± 1.1	2.3 ± 1.2	2.2 ± 1.0
15 June 2012	2.6 ± 0.8	2.6 ± 0.7	2.6 ± 0.6
30 June 2012	2.6 ± 0.8	2.7 ± 0.8	2.6 ± 0.7
Mean	2.6 ± 0.8	2.6 ± 0.7	2.6 ± 0.6

Means per sampling month in the columns and lines do not differ by the Scott–Knott test at 5% probability. Caterpillars of early instars were observed in March and April, those of intermediate instars in May, and those of last instar in June.

ples and crops (HB and RC; Table 2). The number of shelters constructed using one and four leaves were less. First- or middle-instar caterpillars usually build shelters using two leaves, and another one or two are incorporated because they are required for feeding and protection.

Frequency of the *Stenoma* sp. The frequency of *Stenoma* sp. caterpillars was similar among samples and crops (HB and RC; Table 3). Larger, last-instar caterpillars were more frequent in groups with fewer individuals, while the opposite was observed for the first-instar caterpillars.

Emergence of the Parasitoids. This is the first record of *E. tenuigena* parasitizing *P. brasiliensis* caterpillars.

Table 3. Frequency (mean ± SE) of the groups from 5 to 11 last-instar caterpillars of *Stenoma* sp. (Lepidoptera: Elachistidae) per quadrant in the two crops of *C. kummeriana* (Marantaceae), in the HB and RC, in the campus of the UFV, Viçosa, Minas Gerais State, Brazil

Sampling date	HB	RC	Mean
15 June 2011	9 ± 0.9	8 ± 0.7	8 ± 0.6
30 June 2011	8 ± 0.8	7 ± 0.7	7 ± 0.8
Mean	8 ± 0.8	7 ± 0.7	7 ± 0.7
15 March 2012	10 ± 0.5	9 ± 0.4	10 ± 0.9
31 March 2012	10 ± 0.8	10 ± 1.0	10 ± 0.8
Mean	10 ± 0.6	9.5 ± 0.7	10 ± 0.8
15 April 2012	10 ± 0.9	10 ± 0.6	9 ± 1.0
30 April 2012	9 ± 0.8	9 ± 0.6	10 ± 0.5
Mean	9.5 ± 0.8	9.5 ± 0.6	9.5 ± 0.7
15 May 2012	9 ± 1.0	9 ± 0.9	10 ± 0.8
31 May 2012	9 ± 0.8	8 ± 0.9	9 ± 0.9
Mean	9 ± 0.7	8.5 ± 0.9	9.5 ± 0.8
15 June 2012	8 ± 0.8	7 ± 0.6	7 ± 0.7
30 June 2012	9 ± 0.8	8 ± 0.8	8 ± 0.8
Mean	8.5 ± 0.8	7.5 ± 0.7	7.5 ± 0.7

Means per sampling month in the columns and lines do not differ by the Scott-Knott test at 5% probability. Caterpillars of early instars were observed in March and April, those of intermediate instars in May, and those of last instar in June.

Table 4. Emergence (mean, %) of *E. tenuigena* (Hymenoptera: Ichneumonidae) from pupae of *P. brasiliensis* (Lepidoptera: Saturniidae) in the two crops of *C. kummeriana* (Marantaceae), in the HB and RB, in the campus of the UFV, Viçosa, Minas Gerais State, Brazil

Sampling date	HB	RC	Mean
15 June 2011	70	70	70
30 June 2011	80	70	75
Mean	75	70	72.5
15 June 2012	70	80	75
30 June 2012	90	80	85
Mean	80	80	80

Means per sampling month in the columns and lines do not differ by the Scott–Knott test at 5% probability.

However, parasitoids were not observed on the pupae of *Stenoma* sp. The emergence of *E. tenuigena* from *P. brasiliensis* pupae collected in June 2011 and 2012, was 72.5 and 80.0%, respectively, which was similar among the samples and crops (HB and RC; Table 4). The emergence of *E. tenuigena* (cenobiont parasitoid) from pupae of *P. brasiliensis*, and the bristle growth of caterpillars from the third instar as a means of protection suggest that this parasitoid attacks early-instar caterpillars of this host.

Emergence of the Lepidopterans. The emergence from the pupae collected in June 2011 and 2012 was 27.5 and 20.0%, respectively, for *P. brasiliensis* and 17.5 and 17.5%, respectively, for *Stenoma* sp. (Table 5).

Infeasibility of Pupae. The infeasibility of the *Stenoma* sp. pupae was 82.5 and 80.0% in June 2011 and 2012, respectively, similar to the values among the samples and crops (HB and RC; Table 6).

Morphologic Diagnosis. *E. tenuigena* is one of the largest species of the subfamily Ophioninae with forewing length between 16 and 25 mm and a brown-yellowish body (Fig. 5A). Five characteristic features that help to identify this parasitoid are as following: 1) metapleura with fine and close striae; 2) concentrically rugose propodeum, without posterior transverse

Table 5. Emergence (mean, %) of *P. brasiliensis* (Lepidoptera: Saturniidae) and *Stenoma* sp. (Lepidoptera: Elachistidae) obtained from last-instar caterpillars collected in the two crops of *C. kummeriana* (Marantaceae), in the HB and RB, in the campus of the UFV, Viçosa, Minas Gerais State, Brazil

Sampling date	HB	RC	Mean
P. brasiliensis			
15 June 2011	30	30	30
30 June 2011	20	30	25
Mean	25	30	27.5
15 June 2012	30	20	25
30 June 2012	10	20	15
Mean	20	20	20
Stenoma sp.			
15 June 2011	20	10	15
30 June 2011	20	20	20
Mean	20	15	17.5
15 June 2012	10	10	10
30 June 2012	30	20	25
Mean	20	15	17.5

Means per sampling month in the columns and lines do not differ by the Scott–Knott test at 5% probability.

Table 6. Unviable pupae (mean, %) of *Stenoma* sp. (Lepidoptera: Elachistidae) obtained from last-instar caterpillars collected in the two crops of *C. kummeriana* (Marantaceae), in the HB and RB, in the campus of the UFV, Viçosa, Minas Gerais State, Brazil

Sampling date	HB	RC	Mean
15 June 2011	80	90	85
30 June 2011	80	80	80
Mean	80	85	82.5
15 June 2012	80	90	85
30 June 2012	70	80	75
Mean	75	85	80

Means of the same sampling month in the columns and lines do not differ by the Scott–Knott test at 5% probability.

carina (Fig. 5B); 3) posterior tarsal claws quite abruptly curved at the apex; 4) forewing showing no evidence of sclerites in discosubmarginal cell; and 5) *Rs+2r* vein strongly sinuous in the central portion (Fig. 5C).

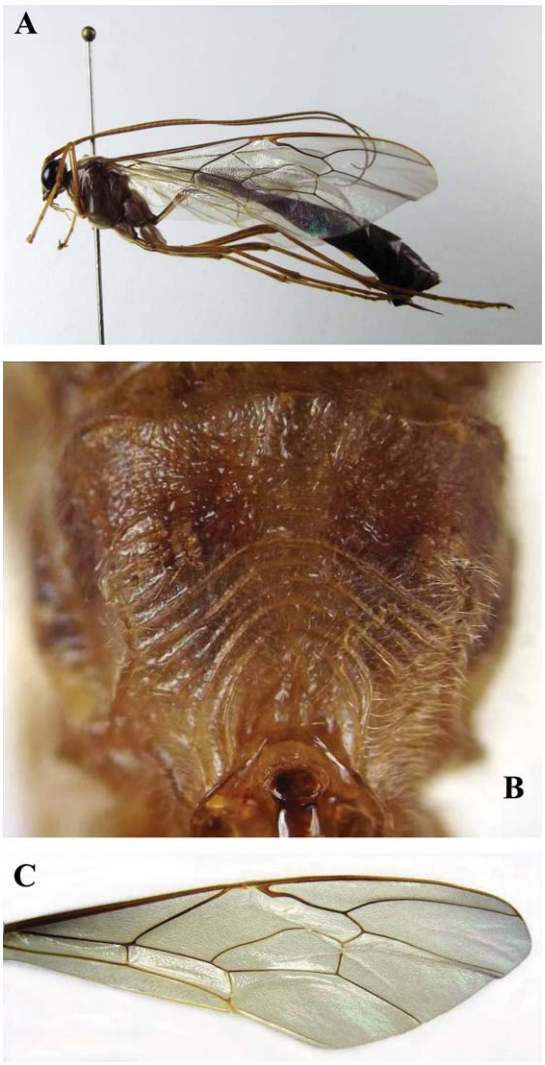

Fig. 5. Female (A), propodeum (B), and forewing (C) of *E. tenuigena* (Hymenoptera: Ichneumonidae). (Online figure in color.)

Discussion

P. brasiliensis and *Stenoma* sp. thrive in moist and shady places, where the *C. kummeriana* crops are best adapted (Specht et al. 2005, de Lima and Moura 2008).

The occurrence of *P. brasiliensis* in Viçosa includes the Atlantic Rainforest in the distribution areas of this insect, which has been reported in the Cerrado region, Brasília, Brazil (de Camargo and Becker 1999). The shelters, built using *C. kummeriana* leaves by the caterpillars of the *Stenoma* sp., serve as food, protection against luminosity and natural enemies, and as a means to maintain the moisture.

The low moisture content of *C. kummeriana* during the dry season (July–September) cause the concentration of toxic substances (polyphenols) of secondary metabolism (Abdullah et al. 2008, Saruhan et al. 2009); thus, rendering this plant more unpalatable to herbivores. This explains the high occurrence of both insect species during the wet season (March–June). Toxic substances from the Zingiberales include the chlorogenic acid, rosmarinic acids, and rutin (Abdullah et al. 2008, Petacci et al. 2012). Rosmarinic acid inhibits the insecticidal activity of *Bacillus thuringiensis* Berliner, 1915 (Bacillales: Bacillaceae) on *Spodoptera litura* F., 1775 (Lepidoptera: Noctuidae; Isayama et al. 2011), but the association of this substance with chlorogenic acid and rutin is toxic to this pest (Mallikarjuna et al. 2004). Moreover, the *C. kummeriana* leaves remain almost upright during the dry season, which would reduce water loss. This architecture may not favor shelter construction by the *Stenoma* sp.

The highest frequency of last-instar caterpillars of the *Stenoma* sp. in groups with lesser numbers of individuals in June could be because of natural mortality factors from March to May. The natural mortality of caterpillars of *P. brasiliensis* could be caused by the lack of precipitation (dry season; this insect does not occur from July to September); human pedestrians who kill them during locomotion because of their size, color, and urticating bristles; microorganism (white colored fungi); parasitoid (*E. tenuigena*); and predators (possibly, *Turdus rufiventris* Vieillot, 1818 [Passeriformes: Turdidae] and Araneae). The natural mortality factors of the *Stenoma* sp. caterpillars include the lack of precipitation (dry season), predator (Araneae), and microorganism (white colored fungi). The lepidopteran larva stage is susceptible to natural mortality factors because it is usually longer in duration than the egg, pupa, and adult stages. Moreover, the herbivory produces physical clues (visual signs) and chemicals (odors emitted by the injured plants, feces of herbivores, etc.), while their natural enemies use these as clues to locate their prey or hosts (Ode 2006, Pereira et al. 2010). These natural mortality factors could be used in the life table of *P. brasiliensis* and *Stenoma* sp.

The first record of *P. brasiliensis* and *Stenoma* sp. feeding on *C. kummeriana* could be a rare event, as the

association of Lepidoptera with Marantaceae is scarce, with only two previous reports. Caterpillars of *Taygetis tamyra* Cramer, 1779 (Lepidoptera: Nymphalidae) feed on the *Ischnosiphon* sp. (Marantaceae) in the United States (Murray 2001), and *Eurybia lycisca* Westwood, 1851 (Lepidoptera: Riodinidae) feed on the nectar of *Calathea crotalifera* (Marantaceae) in Austria (Bauder et al. 2011). This record of *P. brasiliensis* on *C. kummeriana* includes an ornamental plant as host for Saturniidae. The number of noncultivated host plants defoliated for species of this family is unknown, though those with agricultural and forest importance are known (Pereira et al. 2008, 2009a). Most defoliators species of this group feed on two or more plant species (Stone 1991) while their parasitoids belong to Diptera and Hymenoptera (Peigler 1994, Pastori et al. 2012, Tavares et al. 2012a).

The proximity between HB and RC and environmental similarity could contribute to the occurrence of both species during the dry period, and with similar distribution and frequency of groups from 5 to 11 last-instar caterpillars of *Stenoma* sp. The occurrence of similar instar caterpillars of this species in the same shelter suggests that the moths do not oviposit in those shelters having eggs and/or caterpillars.

A study of the association between the lepidopteran defoliators and *C. kummeriana* is economically significant, because its leaves are obtained from greenhouse plants grown by collectors and farmers. An floral arrangement using the leaves of this plant along with flowers of *Rosa* spp. (Rosaceae) was marketed at US$12.50 by "Supermercado Escola" in Viçosa (13 February 2013). Caterpillar-induced injuries on the leaves of these plants could trigger financial losses to the producers because even slightly damaged leaves are rejected by the consumers. Injuries by both insects on *C. kummeriana* 30 d after the attack rendered them unfit for both landscaping and marketing. Moreover, the management, including cutting the *C. kummeriana* leaves requires constant manipulation of the plants, when *P. brasiliensis* caterpillars could cause dermatitis. The integrated management of *C. kummeriana* could include cultural methods (cultivation of plants attractive to the natural enemies; early cultivation of plants attractive to pests; plants grown with more spacing may not favor shelter construction by the *Stenoma* sp.; environmental control of the greenhouses; cultivation of plants repellent to pests; and environmental manipulation to favor the biological control by *E. tenuigena*) (Tavares et al. 2011a,e; Costa et al. 2012). The highest number of leaf shelters harboring the last-instar caterpillars of *Stenoma* sp. could be because of their consumption and the need to incorporate one or two leaves for food and protection, which increases injury to the plants.

Parasitism of *E. tenuigena* in 76.25% of *P. brasiliensis* pupae, with only one generation per year of this herbivore on *C. kummeriana*, suggests the efficacy of this natural enemy because of its higher values when compared with those of *E. ramidulus* and others natural enemies in *H. cunea* pupae (0.13 and 2.33% in 2008 and 2009, respectively) in crops of *C. avellana* in Turkey (Sullivan et al. 2010), or with the degrees of parasitism of *Enicospilus* sp. on *M. separata* (34.6% when feeding on *Sorghum* spp. and 17.6% when feeding on *Pennisetum* spp.) in India (Sharma et al. 2002). These results show that the parasitism rates vary among the species of this genus, which can be used in biological control. The mass production and the release of these parasitoids could increase the level of natural biological control in greenhouses as well as in the field (Tavares 2010). The size of the emerged parasitoid (*E. tenuigena*) varied according to the size of the host (*P. brasiliensis*) in the pupa stage. Larger hosts, generally, produce larger parasitoids and with better reproductive potential in future generations (Tavares et al. 2011b,d; 2012a; 2013a,b).

P. brasiliensis and *Stenoma* sp. defoliated the *C. kummeriana* plants cultivated for landscaping and commercial floriculture; however, *E. tenuigena* parasitized the caterpillars and emerged from the pupae of the first species, which reduced its populations.

Acknowledgments

To Agricultural Engineering Department of the UFV, especially, the National Department of Meteorology by the weather reports of Viçosa; boldsystems.org by the Fig. 2F; "Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq)", "Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES)", and "Fundação de Amparo a Pesquisa do Estado de Minas Gerais (FAPEMIG)" for financial support. Global Edico Services of India corrected and rewrote the English of this manuscript.

References Cited

Abdullah, Y., B. Schneider, and M. Petersen. 2008. Occurrence of rosmarinic acid, chlorogenic acid and rutin in Marantaceae species. Phytochem. Lett. 1: 199–203.

Anderson, V. L., and R. A. McLean. 1974. Design of experiments: a realistic approach. Marcel Deker, Inc., New York, NY, p. 418.

Bauder, J.A.S., N. R. Lieskonig, and H. W. Krenn. 2011. The extremely long-tongued Neotropical butterfly *Eurybia lycisca* (Riodinidae): proboscis morphology and flower handling. Arthropod Struct. Dev. 40: 122–127.

Costa, M. A., W. S. Tavares, A.I.A. Pereira, I. Cruz, J. E. Serrão, and J. C. Zanuncio. 2012. *Chrysoperla externa* (Neuroptera: Chrysopidae) and *Utetheisa ornatrix* (Lepidoptera: Arctiidae) on organically grown *Crotalaria juncea* (Fabaceae). Planta Daninha 30: 459–468.

de Camargo, A.J.A., and V. O. Becker. 1999. Saturniidae (Lepidoptera) from the Brazilian Cerrado: composition and biogeographic relationships. Biotropica 31: 696–705.

de Lima, R.A.F., and L. C. de Moura. 2008. Gap disturbance regime and composition in the Atlantic Montane Rain Forest: the influence of topography. Plant Ecol. 197: 239–253.

Diniz, I. R., B. Higgins, and H. C. Morais. 2011. How do frequent fires in the Cerrado alter the lepidopteran community? Biodivers. Conserv. 20: 1415–1426.

Gauld, I. D. 1988. A survey of the Ophioninae (Hymenoptera, Ichneumonidae) of tropical Mesoamerica with special reference to the fauna of Costa Rica. Bull. Br. Mus. (Natur. Hist.). Entomol. 51: 1–309.

Isayama, S., T. Suzuki, M. Nakai, and Y. Kunimi. 2011. Influences of tannic acid and polyphenols in the leaves of strawberry, *Fragaria* × *ananassa*, and perilla, *Perilla frutescens viridis* on the insecticidal activity of *Bacillus thuringiensis* formulation against the common cutworm, *Spodoptera litura* (Lepidoptera: Noctuidae). Jpn. J. Appl. Entomol. Zool. 55: 49–57.

Lemaire, C. 2002. Les Saturniidae of America. Les Saturniidae Americains (=Attacinae). Hemileucinae, part 1. Goecke and Evers, Keltern, Germany, p. 688.

Lima, A. R., C. M. Jacobi, and A. F. Kumagai. 2012. A key to the Neotropical species of the *Enicospilus ramidulus* species-group (Hymenoptera: Ichneumonidae: Ophioninae), with the description of a new Brazilian species. Zootaxa 3409: 63–68.

Link, D., and F. M. Link. 2008. Identification of host plants of the avocado borer, *Stenoma catenifer* Walsingham (Lepidoptera: Elachistidae) in Rio Grande do Sul. Neotrop. Entomol. 37: 342–344.

Mailafiya, D. M., B. P. Le Ru, E. W. Kairu, P. A. Calatayud, and S. Dupas. 2009. Species diversity of lepidopteran stem borer parasitoids in cultivated and natural habitats in Kenya. J. Appl. Entomol. 133: 416–429.

Mallikarjuna, N., K. R. Kranthi, D. R. Jadhav, S. Kranthi, and S. Chandra. 2004. Influence of foliar chemical compounds on the development of *Spodoptera litura* (Fab.) in interspecific derivatives of groundnut. J. Appl. Entomol. 128: 321–328.

Morais, H. C., B. C. Cabral, J. A. Mangabeira, and I. R. Diniz. 2007. Temporal and spatial variation of *Stenoma cathosiota* Meyrick (Lepidoptera: Elachistidae) caterpillar abundance in the Cerrado of Brasilia, Brazil. Neotrop. Entomol. 36: 843–847.

Murray, D. 2001. Immature stages and biology of *Taygetis* Hubner (Lepidoptera: Nymphalidae). Proc. Entomol. Soc. Wash. 103: 932–945.

Nava, D. E., J.R.P. Parra, V. A. Costa, T. M. Guerra, and F. L. Cônsoli. 2005. Population dynamics of *Stenoma catenifer* (Lepidoptera: Elachistidae) and related larval parasitoids in Minas Gerais, Brazil. Fla. Entomol. 88: 441–446.

Nava, D. E., J.R.P. Parra, J.M.S. Bento, G. I. Diez-Rodriguez, and M. L. Haddad. 2006. Vertical distribution, damage and cultural control of *Stenoma catenifer* Walsingham (Lepidoptera: Elachistidae) in avocado grove. Neotrop. Entomol. 35: 516–522.

Ode, P. J. 2006. Plant chemistry and natural enemy fitness: effects on herbivore and natural enemy interactions. Annu. Rev. Entomol. 51: 163–185.

Ostle, B., and R. W. Mensing. 1975. Statistics in research, 3rd ed. Iowa State University Press, Ames, IA, p. 596.

Pastori, P. L., F. F. Pereira, G. S. Andrade, R. O. Silva, J. C. Zanuncio, and A.I.A. Pereira. 2012. Reproduction of *Trichospilus diatraeae* (Hymenoptera: Eulophidae) in pupae of two lepidopterans defoliators of eucalypt. Rev. Colomb. Entomol. 38: 91–93.

Peigler, R. S. 1994. Catalog of parasitoids of Saturniidae of the world. J. Res. Lepid. 33: 1–121.

Pereira, F. F., J.P.D.M. Felipe, G. D. Canevari, O.H.H. Mielke, J. C. Zanuncio, and J. E. Serrão. 2008. Biological aspects of *Dirphia moderata* (Lepidoptera: Saturniidae) on *Eucalyptus cloeziana* and *Psidium guajava*. Braz. Arch. Biol. Technol. 51: 369–372.

Pereira, A.I.A., C.R.D. Curvêlo, A.M.N.M. Guerra, G. S. Andrade, and J. C. Zanuncio. 2009a. *Eucalyptus cloeziana* as a new host to *Hylesia paulex* (Lepidoptera: Saturniidae) in southeast Brazil. Rev. Caatinga 22: 1–5.

Pereira, A.I.A., J. C. Zanuncio, H. R. Gil-Santana, F. S. Ramalho, G.L.D Leite, and J. E. Serrão. 2009b. *Harpactor angulosus* (Reduviidae: Harpactorinae), a predator of *Neotropical saturniids, Hylesia* spp. in Brazil. Entomol. News 120: 206–212.

Pereira, A.I.A., V. V. Zanuncio, A. S. Lorenzon, H. Bolognani, B. V. Fernandes, O.H.H. Mielke, J. E. Serrão, and J. C. Zanuncio. 2009c. Biological and morphological characteristics of *Hylesia paulex* (Lepidoptera: Saturniidae) fed with *Eucalyptus urophylla* (Myrtaceae). Interciência 34: 645–649.

Pereira, A.I.A., C.R.D. Curvêlo, D. R. Smith, J.M.M. Pereira, T. V. Zanuncio, and J. C. Zanuncio. 2010. Natural mortality factors of the Neotropical Symphyta *Haplostegus nigricrus* (Hymenoptera: Pergidae). Biosci. J. 26: 115–120.

Petacci, F., W. S. Tavares, S. S. Freitas, A. M. Teles, J. E. Serrão, and J. C. Zanuncio. 2012. Phytochemistry and quantification of polyphenols in extracts of the Asteraceae weeds from Diamantina, Minas Gerais State, Brazil. Planta Daninha 30: 9–15.

[SAEG] Sistema para Análises Estatísticas. 2007. Versão 9.1: Fundação Arthur Bernardes - UFV - Viçosa.

Saruhan, N., R. Terzi, A. Saglam, and A. Kadioglu. 2009. The relationship between leaf rolling and ascorbate-glutathione cycle enzymes in apoplastic and symplastic areas of *Ctenanthe setosa* subjected to drought stress. Biol. Res. 42: 315–326.

Sharma, H. C., D. J. Sullivan, and V. S. Bhatnagar. 2002. Population dynamics and natural mortality factors of the Oriental armyworm, *Mythimna separata* (Lepidoptera: Noctuidae), in south-central India. Crop Prot. 21: 721–732.

Specht, A., E. Corseuil, and A. C. Formentini. 2005. Lepidopterans of medical importance from Rio Grande do Sul State. III. Saturniidae – Hemileucinae. Biociências 13: 149–162.

Stone, S. E. 1991. Foodplants of world Saturniidae. Lepid. Soc. Mem. 4: 1–186.

Sullivan, G. T., I. Karaca, S. K. Ozman-Sullivan, and J. Kolarov. 2010. Ichneumonid (Hymenoptera) parasitoids of overwintering *Hyphantria cunea* (Drury) (Lepidoptera: Arctiidae) pupae in hazelnut plantations of the central Black Sea region of Turkey. Zootaxa 2608: 63–68.

Tavares, W. S. 2010. Costs of a biofactory of *Trichogramma pretiosum* Riley for the control of fall armyworm in maize. EntomoBrasilis 3: 49–54.

Tavares, W. S., I. Cruz, J. E. Serrão, and J. C. Zanuncio. 2011a. *Crotalaria juncea* (L.) (Fabaceae). Trends Entomol. 7: 37–44.

Tavares, W. D., C. Hansson, J. E. Serrão, and J. C. Zanuncio. 2011b. First report of *Trichospilus pupivorus* (Hymenoptera: Eulophidae) parasitizing pupae of *Anticarsia gemmatalis* (Lepidoptera: Noctuidae). Entomol. Gen. 33: 281–282.

Tavares, W. S., J. E. Serrão, R. A. Barbosa, and J. C. Zanuncio. 2011c. *Lagerstroemia speciosa* (L.) Pers. (Lythraceae), a new host for the defoliator *Oiketicus kirbyi* Guilding, [1827] (Lepidoptera: Psychidae). Trop. Lepid. Res. 21: 100–104.

Tavares, W. D., T. V. Zanuncio, C. Hansson, J. E. Serrão, and J. C. Zanuncio. 2011d. Emergence of *Palmistichus elaeisis* (Hymenoptera: Eulophidae) from pupae of *Thagona tibialis* (Lepidoptera: Lymantriidae) collected in the medicinal plant *Terminalia catappa* (Combretaceae). Entomol. News 122: 250–256.

Tavares, W. S., I. Cruz, R. B. Silva, M.L.C. Figueiredo, F. S. Ramalho, J. E. Serrão, and J. C. Zanuncio. 2011e. Soil organisms associated to the weed suppressant *Crotalaria juncea* (Fabaceae) and its importance as a refuge for natural enemies. Planta Daninha 29: 473–479.

Tavares, W. D., O.H.H. Mielke, C. F. Wilcken, L. Simon, J. E. Serrão, and J. C. Zanuncio. 2012a. *Palmistichus elaeisis* (Hymenoptera: Eulophidae) parasitizing pupae of *Citioica anthonilis* (Lepidoptera: Saturniidae) collected on *Piptadenia gonoacantha* (Fabaceae). J. Lepid. Soc. 66: 216–220.

Tavares, W. D., G. Salgado-Neto, J. C. Legaspi, F. D. Ramalho, J. E. Serrão, and J. C. Zanuncio. 2012b. Biological and ecological consequences of *Diolcogaster* sp. (Hymenoptera: Braconidae) parasitizing *Agaraea minuta* (Lepidoptera: Arctiidae) and the effects on two *Costus* (Costaceae) plant species in Brazil. Fla. Entomol. 95: 966–970.

Tavares, W. S., C. Hansson, O.H.H. Mielke, J. E. Serrão, and J. C. Zanuncio. 2013a. Parasitism of *Palmistichus elaeisis* Delvare & LaSalle, 1993 on pupae of *Methona themisto* (Hübner, [1818]) reared on two hosts (Lepidoptera: Nymphalidae; Hymenoptera: Eulophidae). SHILAP-Rev. Lepid. 41: 43–48.

Tavares, W. S., M. A. Soares, O.H.H. Mielke, J.C.M. Poderoso, J. E. Serrão, and J. C. Zanuncio. 2013b. Emergence of *Palmistichus elaeisis* Delvare & LaSalle, 1993 (Hymenoptera: Eulophidae) from pupae of *Heraclides anchisiades capys* (Hübner, [1809]) (Lepidoptera: Papilionidae) in the laboratory. Folia Biol. Krakow 61: 233–237.

Varanda, E. M., A. A. Costa, and J. R. Barosela. 2008. Leaf development in *Xylopia aromatica* (Lam) Mart. (Annonaceae): implications for palatability to *Stenoma scitiorella* Walker 1864 (Lepidoptera: Elachistidae). Braz. J. Biol. 68: 831–836.

Veiga, A.B.G., B. Blochtein, and J. A. Guimarães. 2001. Structures involved in production, secretion and injection of the venom produced by the caterpillar *Lonomia obliqua* (Lepidoptera, Saturniidae). Toxicon 39: 1343–1351.

Received 23 April 2013; accepted 18 October 2013.