Sarsina violascens spatial and temporal distributions affected by native vegetation strips in eucalyptus plantations

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Abstract – The objective of this work was to evaluate spatial and temporal distributions of *Sarsina violascens* (Lepidoptera: Noctuidae: Lymantriinae) in two *Eucalyptus cloeziana* plantations, one with native vegetation strips (WNVS) and another without them (ONVS). Adults were collected with light traps, which were installed: inside an area of native vegetation (Cerrado), 100 m from the edge; at the contact zone between the native vegetation area and the *E. cloeziana* plantation; inside the *E. cloeziana* plantation, 250 m from the edge; at the central part of the native vegetation strip, around 500 m from the edge (WNVS) or in the contact zone between two *E. cloeziana* compartments (ONVS); and inside the *E. cloeziana* plantation, 500 m from the edge. The number of *S. violascens* adults collected was 240 in the system WNVS and 1,378 in the system ONVS. The lower number of individuals in the system WNVS was probably due to favored biological control provided by higher species richness with the use of native vegetation strips. These strips, intermingled with *E. cloeziana* plantations, allow a higher proportion of native forest in the landscape and can help to reduce *S. violascens* infestations.

Index terms: *Eucalyptus cloeziana*, *Sarsina violascens*, habitat fragmentation, integrated pest management, plant species richness, population dynamics.

Distribuição espacial e temporal de *Sarsina violascens* influenciada por faixas de vegetação nativa em plantações de eucalipto

Resumo – O objetivo deste trabalho foi avaliar a distribuição espacial e temporal de *Sarsina violascens* (Lepidoptera: Noctuidae: Lymantriinae) em duas plantações de *Eucalyptus cloeziana*, uma com faixas de vegetação nativa (CFVN) e outra sem (SFVN). Adultos foram coletados com armadilhas luminosas, as quais foram instaladas: no interior de uma área com vegetação nativa (Cerrado), a 100 m da borda; na zona de contato entre a vegetação nativa e a plantação de *E. cloeziana*; no interior da plantação de *E. cloeziana*, a 250 m da borda; na parte central da faixa de vegetação nativa, cerca de 500 m da borda (CFVN) ou na zona de contato entre dois talhões de *E. cloeziana* (SFVN); e no interior da plantação de *E. cloeziana*, a 500 m da borda. O número de adultos de *S. violascens* coletados foi de 240 no sistema CFVN e de 1.378 no sistema SFVN. O menor número de indivíduos no sistema CFVN provavelmente foi devido ao favorecimento do controle biológico pelo aumento da riqueza de espécies com o uso de faixas de vegetação nativa. Essas faixas, intercaladas com plantações de *E. cloeziana*, possibilitam maior proporção de floresta nativa na paisagem e podem auxiliar na redução de infestações por *S. violascens*.

Termos para indexação: *Eucalyptus cloeziana*, *Sarsina violascens*, fragmentação do habitat, manejo integrado de pragas, riqueza de espécies de plantas, dinâmica populacional.

Introduction

The spatial distribution of insect outbreaks in *Eucalyptus* spp. (Myrtales: Myrtaceae) plantations can be aggregated, random, or uniform (Silva et al., 2014), and rainfall and temperature are the main factors affecting the temporal distribution of lepidopteran pests (Zanuncio et al., 2000). Knowledge of the spatial and temporal distributions of forest insect outbreaks is fundamental for using the proper control methods,

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determining damage level, incorporating spatial dynamics within the population model, and optimizing sampling techniques (Zanuncio et al., 2000; Silva et al., 2014).

In Brazil, leaf-cutting ants (Hymenoptera: Formicidae) are the main pests of *Eucalyptus* spp. (Souza et al., 2011; Zanetti et al., 2014), but the importance of lepidopteran and coleopteran defoliators has increased (Euzebio et al., 2013; Zanuncio et al., 2013a, 2013b). This made it necessary to study the natural mechanisms that can regulate lepidopteran populations in *Eucalyptus* spp. plantations close to areas with native vegetation strips (Dall'Oglio et al., 2013; Macedo-Reis et al., 2013; Ribeiro et al., 2013).

Sarsina (Lepidoptera: Lymantriinae) is a Neotropical genus of Noctuidae, with 8–10 species superficially described, native to Mexico and Central and South Americas. *Sarsina violascens* (Herrich-Schäeffer, 1856) (Lepidoptera: Noctuidae: Lymantriinae) occurs from the south of Mexico to Argentina. This insect is an important pest in central Brazil and in portions of Mexico where *Eucalyptus* spp. plantations are established (Ciesla, 2011). In Brazil, this species is widely distributed in the states of: Bahia, in the Northeast Region; Espírito Santo, Minas Gerais, and São Paulo, in the Southeast Region; Pará, in the North Region; and Paraná, Rio Grande do Sul, and Santa Catarina, in the South Region (Zanuncio et al., 2000; Bernardi et al., 2011). In Mexico, *S. violascens* has been reported in the states of Tabasco, in the Southeast Region, and of Veracruz, in the South-Central Region (Ciesla, 2011).

Richer environments in plant species generally have a higher number of Lepidoptera species with a lower number of individuals of each species (Zanuncio et al., 2003; Freitas et al., 2005; Zanuncio et al., 2006). The reduction of species homogeneity, with the preservation of the remnants of the native vegetation in *Eucalyptus* spp. plantations (Cunningham et al., 2005; Hawes et al., 2009; Macedo-Reis et al., 2013), represents an important ecological principle for pest management (Pereira et al., 2001; Murta et al., 2008; Ribeiro et al., 2013).

The objective of this work was to evaluate spatial and temporal distributions of *Sarsina violascens* (Lepidoptera: Noctuidae: Lymantriinae) in two *Eucalyptus cloeziana* plantations, one with native vegetation strips (WNVS) and another without them (ONVS).

Materials and Methods

The study was carried out in the following municipalities of the state of Minas Gerais, Brazil: Paineiras (18º57'S, 45°26'W, at a 600-m altitude), in a plantation system WNVS; and Paraopeba (19º17'S, 44°29'W, at a 700-m altitude), in a system ONVS. In the system WNVS, vegetation strips of Cerrado vegetation (25-m width each) were kept every 500 m of reforestation. These strips were connected to each other, to vegetation reserves, or to vegetation islands (400-m width, every 10 ha). Areas near dams, lakes, paths, and waterways were considered of permanent preservation. In a landscape context, the area in Paineiras has a higher proportion of native forest than in Paraopeba.

Paineiras belongs to the central mesoregion of the state of Minas Gerais and to the microregion of the municipality of Três Marias, whereas Paraopeba belongs to the metropolitan mesoregion of the municipality of Belo Horizonte and to the microregion of the municipality of Sete Lagoas, also in the state of Minas Gerais. Both studied areas have tropical climate, classified as Aw according to Köppen, with a dry season. Their native vegetation belongs to the Cerrado biome, and the evaluated areas were located on the soil type Latossolo Vermelho-Amarelo (Oxisol) (Durães et al., 2011).

The botanical families of the species found in the native vegetation strips studied were: Anacardiaceae, Burseraceae, Meliaceae, Rutaceae, and Sapindaceae (Sapindales); Annonaceae and Myristicaceae (Magnoliales); Apocynaceae, Loganiaceae, and Rubiaceae (Gentianales); Aquifoliaceae (Aquifoliales); Araliaceae (Apiales); Arecaceae (Arecales); Asteraceae (Asterales); Bignoniaceae, Boraginaceae, Labiatae, and Verbenaceae (Lamiales); Bixaceae, Bombacaceae, and Tiliaceae (Malvales); Caesalpinioideae, Fabaceae, and Mimosaceae (Fabales); Caryocaraceae, Euphorbiaceae, Guttiferae, Malpighiaceae, and Ochnaceae (Malpighiales); Celastraceae, Hippocrateaceae, and Icacinaceae (Celastrales); Clethraceae, Ebenaceae, Myrsinaceae, Sapotaceae, Styracaceae, and Symplocaceae (Ericales); Combretaceae, Lythraceae, Melastomataceae, Myrtaceae, and Vochysiaceae (Myrtales); Connaraceae (Oxalidales); Dilleniaceae (Dilleniales); Flacourtiaceae (Violales); Lauraceae (Laurales); Moraceae (Rosales); Nyctaginaceae

(Caryophyllales); Opiliaceae (Santalales); Proteaceae (Proteales); and Solanaceae (Solanales).

Lepidopteran individuals were sampled with light traps in the two *E. cloeziana* compartments (WNVS and ONVS). In the beginning of both studies, the trees were two years old and 2.6–4.0-m tall, and were spaced at 3.0×2.5 m. Leaf-cutting ants were controlled with sulfluramid baits, which have no effect on other insects (Zanetti et al., 2008). Vegetation under *E. cloeziana* trees (mostly weeds) was not removed.

Five light traps, model Intral 012 (Intral, Caxias do Sul, RS, Brazil) were installed per system with the help of a global positioning system (GPS): inside an area of native vegetation (Cerrado), 100 m from the edge; at the contact zone between the native vegetation area and the *E. cloeziana* plantation; inside the *E. cloeziana* plantation, 250 m from the edge; at the central part of the native vegetation strip, around 500 m from the edge (WNVS) or in the contact zone between two *E. cloeziana* compartments (ONVS); and inside the *E. cloeziana* plantation, 500 m from the edge. The contact zones between the Cerrado biome and the *E. cloeziana* plantation (WNVS), as well as among *E. cloeziana* compartments (ONVS), corresponded to land roads, approximately 7 m wide. The distance between the traps was at least 250 m, in order to minimize possible interferences between them.

Sarsina violascens adults were collected every 15 days, from October to April, in the five light traps, in both plantation systems. The traps were equipped with a fluorescent black-light bulb, model F15 T12 LN (Havells Sylvania Brasil Iluminação Ltda., São Paulo, SP, Brazil), emitting wavelength from 290 to 450 mm, powered by a 12-V and 55-A battery. They were installed at a 2-m height, considering the midpoint of the lamp length (Zanuncio et al., 2014). The collection period included pre- and post-rain seasons in the studied regions (Durães et al., 2011). The traps were turned on between 18:00 and 19:00 p.m. and turned off between 07:00 and 08:00 a.m. (13-hour operation), since *S. violascens* adults have a nocturnal habit (Dall'Oglio et al., 2013). The collection of the insects was postponed one or two days in case of rain (Dall'Oglio et al., 2013). Captured insects were removed from 20-L plastic bags coupled to a trap funnel. These bags had newspaper strips and an ethyl acetate pot with a wick, to hasten the death and prevent excessive flaking of the insects (Bernardi et al., 2011).

These procedures were based on traits of *S. violascens*. The species can have three generations per year in Mexico, with active life stages during eight months (Ciesla, 2011). However, the number of individuals in the third generation is reduced to low levels due to the control by natural enemies in the first two. In Brazil, adult specimens are active from March to December, depending on local climate. In addition, both sexes fly and are active at night (Zanuncio et al., 2000; Bernardi et al., 2011), and the female deposits up to 40 eggs, singly or in strips, on foliage. The duration of the egg stage is around 11 days, whereas the duration of the larva stage is around 37 days. Larvae have nocturnal habit and congregate on the lower third of boles of host trees during the day, entering a pre-pupa stage for two days when feeding is completed. Pupation lasts around nine days and occurs in foliage, tree trunks, and understory vegetation, i.e., low height vegetation beneath the canopy (Carlos et al., 2010).

Collected *S. violascens* adults were sorted, cataloged, and mounted in the Laboratory of Biological Control of Insects (LCBI) at Universidade Federal de Viçosa (UFV), in the state of Minas Gerais, Brazil. The males and females were deposited in the Regional Museum of Entomology of the institution. The confirmation of species identification was performed by the specialist Dr. Olaf Hermann Hendrik Mielke, of the Department of Zoology of Universidade Federal do Paraná (UFPR), in the state of Paraná, Brazil, after comparisons with keys, taxonomic descriptions (Lafontaine & Fibiger, 2006), and with the material previously deposited at that institution.

The number of *S. violascens* adults captured were recorded fortnightly in the five traps, monthly in each trap, and per collection site in each studied area (WNVS and ONVS), from October 2012 to April 2013. The average temperature and monthly rainfall were obtained monthly from the nearest weather station.

Results and Discussion

The population dynamics of *S. violascens* differed between Paineiras (WNVS) and Paraopeba (ONVS) in samples from October 2012 to April 2013. This dynamics was similar to the one reported for *Oxydia vesulia* (Cramer, 1779) (Lepidoptera: Geometridae) in a similar study in the same regions, from October 1993 to April 1994 (Santos et al., 2002). Native vegetation strips, intermingled with *E. cloeziana* plantations, provided a higher proportion of native forest in the landscape and this probably contributed to the reduction of the number of *S. violascens* adults collected in the light traps: 240 in the system WNVS and 1,378 in the system ONVS (Table 1). The lower number of *S. violascens* adults in the system WNVS suggests that higher plant species richness in the landscape, compared to that of the system ONVS, can maintain a low frequency of this pest species due to biological factors. This agrees with the fact that several small shelters and higher proportions of native forest provide better conditions of biological balance than a few or no native vegetation compartments (Silva et al., 2010; Dall'Oglio et al., 2013; Macedo-Reis et al., 2013). Therefore, the lower occurrence of *S. violascens* individuals in the system WNVS might be explained by the higher heterogeneity in plant species richness and by the higher quantities of sources of pollen, nectar, and alternative hosts in this system, which favors natural enemies (Zanuncio et al., 2009; Macedo-Reis et al., 2013). Additionally, the higher number of *S. violascens* in the system ONVS and the abrupt rise in this number at the end of the sampling period indicate that a more homogeneous plant species richness increases the frequency of organisms. This occurs mainly when *S. violascens* reaches eucalyptus plantations without native vegetation strips, where its number increases rapidly, because of the lower number of biological control agents (Bernardi et al., 2011).

Sarsina violascens showed a more uniform frequency in the system WNVS, with a lower number of individuals from January to April 2013, whereas a higher number of Lepidoptera individuals was observed in the system ONVS in March and April 2013 (Figure 1 A). On the one hand, the reduced number of *S. violascens* individuals collected in the system WNVS throughout the evaluation months indicated that the higher plant species richness and greater proportion of native forest in the landscape in this system contributed to avoid the population explosion of the pest. Furthermore, it showed that this species, despite being able to establish itself in native hosts, is under control in richer plant species environments (Zanuncio et al., 2000; Bernardi et al., 2011). On the other hand, the smaller area with native vegetation in the system ONVS hinders the maintenance of residual populations of *S. violascens*; however, the lower plant species richness and native forest proportion in the landscape favored a population increase of the pest in February 2013, with higher populations in April 2013 (Figure 1 A).

The number of *S. violascens* individuals collected was higher in the third collection site, inside the *E. cloeziana* plantation, in both the systems WNVS and ONVS (Figure 1 B). However, this number was

Table 1. Number of *Sarsina violascens* (Lepidoptera: Noctuidae: Lymantriinae) adults collected with light traps in the first and second fortnights, from October 2012 to April 2013, in *Eucalyptus cloeziana* plantations in systems with (WNVS) and without (ONVS) native vegetation strips.

Trap position[(1)]	October		November		December		January		February		March		April		Total
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	
							WNVS								
Trap 1	1	2	0	0	1	3	1	0	1	0	1	0	0	0	10
Trap 2	0	0	2	4	1	4	6	2	1	4	0	2	1	4	31
Trap 3	0	0	3	3	3	6	13	0	15	17	9	3	6	36	114
Trap 4	0	0	0	1	2	4	0	0	1	0	5	2	1	1	17
Trap 5	0	0	0	2	4	0	12	2	0	14	13	2	0	19	68
Total	1	2	5	10	11	17	32	4	18	35	28	9	8	60	240
							ONVS								
Trap 1	0	0	0	0	0	2	3	3	1	3	12	6	54	42	126
Trap 2	0	0	0	0	2	2	3	4	1	9	15	41	51	191	319
Trap 3	0	1	0	0	1	3	4	4	0	7	43	16	32	432	543
Trap 4	0	1	0	0	1	2	2	1	3	15	31	31	27	81	195
Trap 5	0	0	0	0	0	4	0	0	16	20	17	34	50	54	195
Total	0	2	0	0	4	13	12	12	21	54	118	128	214	800	1,378

[(1)]Trap 1, inside a native vegetation (Cerrado) area, 100 m from the edge; trap 2, at the contact zone between the native vegetation area and the *E. cloeziana* plantation; trap 3, inside the *E. cloeziana* plantation, 250 m from the edge; trap 4, at the central part of the native vegetation strip, around 500 m from the edge (WNVS) or in the contact zone between two *E. cloeziana* compartments (ONVS); and trap 5, inside the *E. cloeziana* plantation, 500 m from the edge.

higher in the collection sites of the system ONVS, and the value and distribution of *S. violascens* individuals per site showed a lower variation in the system WNVS. High populations and outbreaks of pest species, such as *S. violascens*, were linked to factors including low vegetal species richness (Zanuncio et al., 2001, 2003, 2006). The expansion of *Eucalyptus* spp. plantations in areas of the Brazilian Cerrado contributes to this outcome, because the poorer understory favors the unbalance of insect pest populations (Pereira et al., 2009; Silva et al., 2010). The studied species was reported as a dominant one with wide distribution and abundant, floating populations (Zanuncio et al., 2001; Lopes et al., 2007; Bernardi et al., 2011). In addition, its adaptation to *Eucalyptus* spp. is favored, because it is a polyphagous species with many native hosts of the family Myrtaceae (Zanuncio et al., 2000).

Polyphagous species preadapt to a new host according to the chemical, structural, or taxonomic affinities between pests and hosts (Pereira et al., 2001, 2009; Zanuncio et al., 2013b). The majority of *Eucalyptus* spp. pests in Brazil originate from native plants of the family Myrtaceae (Oliveira et al., 2000; Rapley et al., 2004; Withers et al., 2011), but their occurrence may be reduced by improving the environmental stability of homogeneous plantations (Murta et al., 2008; Dall'Oglio et al., 2013; Macedo-Reis et al., 2013). This may be achieved by increasing the populations of the mesofauna, bird fauna, microbiota, and entomofauna, which have important components for biological control (Axmacher et al., 2004; Barlow et al., 2008; Hawes et al., 2009).

Precipitation and temperature, in general, did not affect the number of *S. violascens* individuals in the system WNVS (Figure 2 A), but in the system ONVS, there was an increase at the end of the rainy season (Figure 2 B). Adults were not recorded on some dates in the system ONVS, but their number increased from February 2013 onwards, reaching a population peak (with 800 collected individuals) after two months, in the second half of April 2013, which suggests a lower population stability in more simplified systems.

Intermingling native vegetation with *E. cloeziana* plantations in the system WNVS helped in the reduction of the number of *S. violascens* adults. Moreover, the interconnection of preservation areas by strips and the higher proportion of native vegetation in the landscape can contribute to decrease insulation, which facilitates the dispersion of natural enemies in the environment

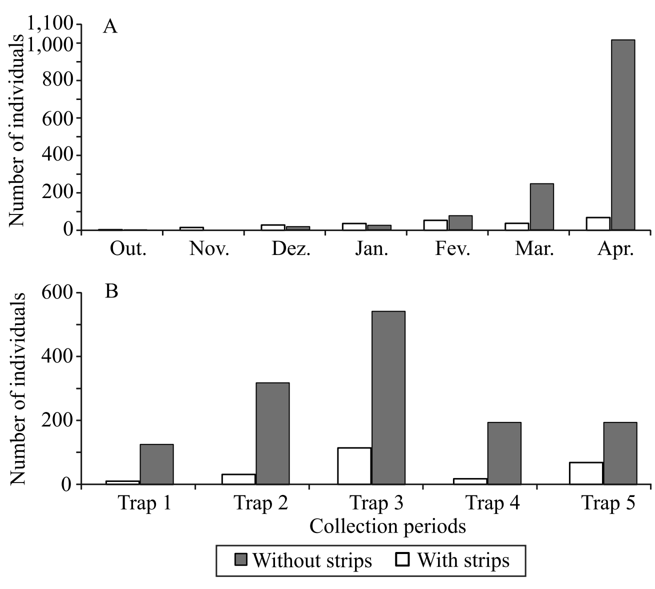

Figure 1. Number of *Sarsina violascens* (Lepidoptera: Noctuidae: Lymantriinae) adults collected, monthly (A) and per collection site (B), with light traps installed in *Eucalyptus cloeziana* plantations with and without native vegetation strips in the state of Minas Gerais, Brazil.

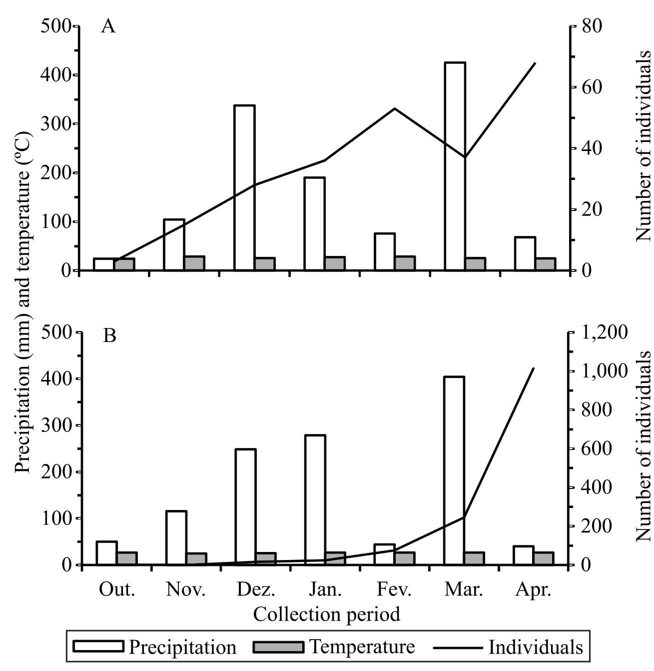

Figure 2. Number of *Sarsina violascens* (Lepidoptera: Noctuidae: Lymantriinae) adults collected with light traps, as well as mean temperature and monthly precipitation, in *Eucalyptus cloeziana* plantations with (A) and without (B) native vegetation strips in the state of Minas Gerais, Brazil.

(Murta et al., 2008; Zanuncio et al., 2009; Tavares et al., 2013). This apparently is the major mechanism for maintaining the insect pests of *Eucalyptus* spp. below the damage level (Soares et al., 2007; Zanuncio et al., 2009), showing the importance of the technique in the integrated management of pests in *Eucalyptus* spp.

Conclusion

Native vegetation strips in forest plantations represent an ecological principle for integrated management of forest pest, and higher proportions in the landscape can help to reduce *Sarsina violascens* infestations in *Eucalyptus* spp. plantations.

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