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ATLANTIC RAINFOREST REMNANT HARBORS GREATER BIOTIC DIVERSITY BUT REDUCED LEPIDOPTERAN POPULATIONS COMPARED TO A *EUCALYPTUS* PLANTATION

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Abstract

Study of the dynamics and distribution of lepidopteran defoliators is important because some of them are major pests of eucalyptus. More than 3,000,000 ha of eucalyptus are now planted in Brazil even though the genus is not native there. The goal of this study was to document the frequency and constancy indexes of lepidopteran pests of *Eucalyptus grandis* Hill ex Maiden (Myrtaceae) collected with 5 light traps (replicates) in different habitats. The first and second traps were installed in a eucalyptus plantation at 400 and 200 m, respectively, from the interface with a native vegetation area (Atlantic Rainforest); the third in the interface and the fourth and the fifth in native vegetation at 200 and 400 m, respectively, from the interface zone. The most frequent primary pest species were *Stenalcidia grosica* Schaus, 1901 (Geometridae) and *Thyrinteina leucoceraea* Rindge, 1961 (Geometridae) with greater frequencies in the eucalyptus plantation at 400 and 200 m from the interface with the native vegetation. In the native vegetation at 200 m from the interface *Oxydia vesulia* Cramer, 1779 (Geometridae) (33.33%) was the most frequently collected primary pest species, and in the interface zone, *Eupseudosoma involuta* Sepp, 1855 (16.27%), and *Eupseudosoma aberrans* Schaus, 1905 (Arctiidae) (15.22%) were the most frequently collected primary pest species. Native vegetation areas of Atlantic Rainforest are more spatially heterogeneous and abundant in host plant species than eucalypt plantations and the high level of species diversity within native vegetation helps to provide natural biological control of herbivorous insects in nearby areas reforested with eucalyptus species.

Key Words: eucalyptus monoculture, Geometridae, habitat fragmentation, Lepidoptera, lepidopteran composition, native vegetation

Resumo

Estudar a dinâmica e distribuição de lepidópteros desfolhadores é importante porque essas espécies são pragas importantes do eucalipto. Mais de três milhões de hectares estão plantados com eucalipto no Brasil, embora esse gênero não seja nativo daqui. O objetivo deste estudo foi documentar os índices de freqüência e constância de lepidópteros pragas de *Eucalyptus grandis* Hill ex Maiden (Myrtaceae) coletados com cinco armadilhas luminosas (repetições) em diferentes habitats. As primeira e segunda armadilhas foram instaladas em um plantio de eucalipto a 400 e 200 metros da transição com uma área de vegetação nativa (Mata Atlântica); a terceira na zona de transição e as quarta e quinta na vegetação nativa a 200 e 400 metros da zona de transição. As espécies de pragas primárias, mais freqüentes, foram *Stenalcidia grosica* Schaus, 1901 e *Thyrinteina leucoceraea* Rindge, 1961 (Geometridae), no plantio de eucalipto a 400 e 200 metros da transição com a vegetação nativa. Na vegetação nativa a 200 metros da transição, *Oxydia vesulia* Cramer, 1779 (Geometridae), com 33,33% e *Eupseudosoma involuta* Sepp, 1855 e *Eupseudosoma aberrans* Schaus, 1905 (Arctiidae), na zona de transição, com 16,27% e 15,22% dos indivíduos coletados, respectivamente, foram as espécies pragas primárias mais freqüentes nesses habitats. Áreas de vegetação nativa de Mata Atlântica são mais espacialmente heterogêneas e abundantes em plantas hospedeiras que em plantações. A elevada diversidade de espécies dentro da vegetação nativa ajuda o controle biológico natural de insetos herbívoros em áreas próximas com espécies de eucaliptos.

Palavras Chave: composição de lepidópteros, fragmentação do habitat, Geometridae, Lepidoptera, monocultura de eucalipto, vegetação nativa

Plantations of eucalyptus (Myrtaceae)—an exotic in Brazil—represent one of the fastest growing sectors of the Brazilian economy with over 3,000,000 ha planted (Stape et al. 2001; Costa et al. 2009; Assis & Resende 2011). Species of this genus can thrive in a wide variety of habitats including those with low water availability and fertility (Stape et al. 2004; Ryan et al. 2010). Eucalyptus is used for reforestation in many countries (Loch & Floyd 2001; Erskine et al. 2005). The abundance of food and low populations of natural enemies can increase the occurrence of insect pests in these plantations (Withers 2001; Cunningham et al. 2005). The importance of these insects can increase because more native species are continuously adapting to *Eucalyptus* spp. plantations (Freitas et al. 2005).

The level of herbivory in a plantation depends on size of insect populations (Stone & Bacon 1994; Vranjic & Ash 1997). These insect populations, in turn, are affected by factors such as migration and dispersal as well as by other variables including the structure of the forest itself, biochemistry, physical and internal plant defenses, and interactions between herbivores and their natural enemies (Jäkel & Roth 2004; Boege & Marquis 2005; Moir et al. 2005). Other factors such as a low number of density dependent factors can lead to population outbreaks of herbivores in monocultures; for example when *Mnesampela privata* Guenée, 1857 (Geometridae) colonizes a eucalyptus plantation in 1 year, its population often erupts to highly damaging levels in the next year during spring/summer (Steinbauer et al. 2001, 2004). Species diversity and population stability are positively correlated with more diverse environments (Steinbauer et al. 2006). Lepidopteran species in these areas can be bioindicators of microclimatic alterations, resource availability and habitat conservation as changes occur in these human-driven processes over time (Wood & Gillman 1998; Kitching et al. 2000; Barlow et al. 2007).

Outbreaks of defoliator lepidopteran pests such as *Apatelodes sericea* Schaus, 1896 (Eupterotidae), *Eupseudosoma involuta* Sepp, 1855 (Arctiidae), *Euselasia apisaon* Dahman, 1823 (Riodinidae), *Psorocampa denticulata* Schaus, 1901 (Notodontidae), *Sarsina violascens* Herrich-Schaeffer, 1856 (Lymantriidae), *Oxydia vesulia* Cramer, 1779, *Sabulodes caberata caberata* Gueneé, 1857 and *Thyrinteina arnobia* Stoll, 1782 (Geometridae) have been documented in eucalyptus plantations in Brazil (Zanuncio et al. 2000; Freitas et al. 2005). Other groups such as those of the superfamily Saturnioidea also have species which damage eucalyptus plants (Zanuncio et al. 2001; Hawes et al. 2009). Light traps are the major sampling method for lepidopteran defoliators of eucalypt plants in Brazil because the majority of the lepidopteran defoliator species are active during the night (Zanuncio et al. 2006).

Native insects migrate from native plants, which present a more diversified fauna than plantations (Rao et al. 2000). Exotic plants, often are associated with reduced numbers of natural enemies (Murta et al. 2008), can be used as favorable ecological niches by insects with high population growth rates. Integrated management of insect pests in eucalyptus plantations in Brazil includes the use of native vegetation remnants intentionally intermingled within plantations in an effort to decrease populations of pests species and to increase populations of their natural enemies (Barlow et al. 2008; Silva et al. 2010). Maintaining or planting areas with native vegetation can favor the multiplication and distribution of natural enemies of lepidopteran defoliators, which can then reduce defoliator populations in forest plantations (Zanuncio et al. 1998a; Gamez-Virues et al. 2008).

Frequency and constancy indexes of primary and secondary lepidopteran pests were studied in 3 habitats, viz: (i) a *Eucalyptus grandis* Hill ex Maiden plantation, (ii) in the interface of this eucalyptus plantation with an area of native vegetation (edge) (Brazilian Atlantic Rainforest biome), and (iii) in areas of native vegetation. The overall objective was to test the hypothesis that the heterogeneity of native vegetation affects population densities of lepidopteran defoliators in eucalypt plantations.

Material and Methods

Study Area

The research was conducted in an *E. grandis* and *Eucalyptus torelliana* F. Muell. plantation with 2,909.65 ha in the Vale do Rio Doce in Ipaba, Minas Gerais State, Brazil at S 19° 20'

W 45° 25' and 213 m asl, and in fragments of secondary forest with high anthropic impact (Atlantic Rainforest) with 1,363.83 ha. The climate of this region has 2 well defined seasons: one hot and humid (Oct to May) and the other cold and dry (Apr to Sep) with a minimum temperature of 13.5 °C and maximum temperature of 34.6 °C and monthly rainfall ranging from 0 to 112 mm.

Lepidopteran individuals were sampled in a eucalyptus stand with an area of 20.09 ha with 3 × 2 m tree spacing. This timber stand was 7 years old at the beginning of the study. Cultural treatments were not made during the study except for the control of leaf cutting ants with sulfuramid baits (Zanetti et al. 2008). Vegetation under eucalyptus trees was not removed.

Sampling Procedures

Lepidopterans were sampled in each locale with 5 light traps using 12 volt batteries and a fluorescent black light (INTRAL AL 012-model, 12 volts) with 1 collection every 15 days from Apr 1997 to Mar 1998. Sampling points were marked every 200 m along a transect through the eucalyptus stand and across the fragment of native vegetation with the help of a global positioning system (GPS).

Five sampling points were established in each locale. The first and second traps were situated in the eucalyptus stand at 400 and 200 m, respectively, from the interface zone (border between plantation and native vegetation) (Eg400 and Eg200); the third trap was set at the interface between eucalypt and native vegetation (Bor), and the fourth and fifth were placed inside the fragment of the native vegetation at 200 and 400 m, respectively, from the interface of this area with the eucalyptus (Vn200 and Vn400). Light traps were placed 2 m high on eucalyptus plants (plantation) or on native Myrtaceae plants (native vegetation area).

The traps were turned on every 15 days during 1 night starting at 6:00 PM and turned off the following morning (7:00 AM) when the insects were removed (13 hours of operation). Collections were postponed 1 or 2 days in case of rain. The insects were collected in a plastic bag (20 L) with fragments of journal pages (15 cm) treated with ethyl acetate fixed at the funnel at the base of the light traps to reduce damage to the collected insects (Zanuncio et al. 1998a). Insects were sorted by habitat and date of collection and sent to Federal University of Viçosa, Animal Biology Department in Viçosa, Minas Gerais State, Brazil where they were counted and classified and those in good conditions sent to Federal University of Paraná, Zoology Department, Curitiba, Paraná State, Brazil and Uiraçu Institute, Camacan, Bahia, Brazil for identification.

Statistical Analysis

The annual totals and averages of insects and species captured per light trap in the 5 sampling sites were determined. The main lepidopteran species from the eucalyptus plantations were divided into primary and secondary pests (Zanuncio et al. 1998b, 2006). Species with no importance defined for eucalyptus plantations and those unidentified were not evaluated. The first group represents species reported in outbreaks in Brazil and that caused economic and environmental damage. The second group includes species with potential to become pests by feeding on eucalyptus, but with reduced numbers or low frequencies.

Frequency and constancy faunal indices were calculated for each pest species (Pereira et al. 2001; Zanuncio et al. 2003). The frequency was calculated with the formula $F = (n \div t) \times 100$, where F is the frequency index, n the total number of individuals collected per species and t the total number of individuals collected. The constancy index (C) was calculated with the formula $C = (p \div n) \times 100$, where p is the number of samples with the species and n the total number of individuals collected. The species collected were grouped as constants, incidental or accidental when present in more than 50%, between 25 and 50% or less than 25% of the samples, respectively. The diversity was obtained by the Shannon index (H'). The data of the number of species were submitted to the χ^2 test and the diversity indices to variance analysis (ANOVA) and the means compared by Tukey's multiple range test.

Results

Number of Individuals of Primary and Secondary Lepidopteran Pest Species

The proportions of pest species from within the plantation of eucalyptus to within the native vegetation were presented. A total of 2,039 individuals of 22 pest species of 13 primary (group I) and 9 secondary (group II) pests was collected with 44.00% and 34.38% in the eucalyptus at 200 and 400 m from the interface; 18.68% at the interface and 1.47% and 1.47% inside the native vegetation at 200 and 400 m from this interface. The proportion of pests was greater in the plantation of eucalyptus than in the native vegetation along the transect (Table 1).

The number of individuals of eucalyptus pest species was greater at sampling points Eg200, Eg400 and Bor with 897 (44.0%), 701 (34.38%) and 381 (18.68%) individuals, respectively (Table 1). Primary pests showed a greater number of species at point Eg400 and of individuals at Eg200 with values of 12 and 796, respectively, while the numbers of species and individuals of secondary pests were greater at point Eg200 with values of 8 and 101, respectively (Fig. 1).

TABLE 1. NUMBER OF INDIVIDUALS OF PRIMARY AND SECONDARY LEPIDOPTERAN PEST SPECIES IN THE EUCALYPT MONOCULTURE AND THE NATIVE VEGETATION AT EACH SAMPLING POINT IN IPABA, MINAS GERAIS STATE, BRAZIL FROM APR 1997 TO MAR 1998.

Family	Species	Eg400	Eg200	Bor	Vn200	Vn400	Total
	Group I – Primary Pests						
Arctiidae	*Eupseudosoma aberrans*	8	50	58	0	0	116
	Eupseudosoma involuta	13	47	62	0	1	123
Geometridae	*Glena bipennaria bipennaria*	21	39	14	1	0	75
	Glena sp.	9	3	4	0	0	16
	Oxydia vesulia	71	117	38	10	5	241
	Sabulodes caberata caberata	0	0	1	1	0	2
	Stenalcidia grosica	315	372	112	8	5	812
	Thyrinteina arnobia	5	7	0	1	0	13
	Thyrinteina leucoceraea	176	115	33	2	4	330
Lymantriidae	*Sarsina violascens*	6	19	9	0	1	35
Notodontidae	*Blera varana*	2	3	0	0	0	5
	Misogada blerura	3	24	8	1	0	36
	Nystalea nyseus	2	0	1	0	1	4
Total of Group I		631	796	340	24	17	1,808
	Group II – Secondary Pests						
Arctiidae	*Idalus admirabilis*	38	71	24	0	1	134
Geometridae	*Iridopsis syrniaria*	25	16	8	1	0	50
Saturniidae	*Automeris illustris*	2	2	4	5	9	22
	Automeris melanops	0	1	2	0	0	3
	Eacles ducalis	0	2	2	0	0	4
	Eacles imperialis magnifica	0	2	0	0	0	2
	Hyperchiria incisa	5	5	0	0	2	12
	Lonomia faleata	0	0	1	0	0	1
Stenomatidae	*Timocratica palpalis*	0	2	0	0	1	3
Total of Group II		70	101	41	6	13	231
Total		701	897	381	30	30	2,039
Frequency (%)		34.38	44.00	18.68	01.47	01.47	100.00

The sampling points were designated as follows: eucalyptus at 400 m from the interface (Eg400), eucalyptus at 200 m from the interface (Eg200), interface of eucalyptus and native vegetation (Bor), native vegetation at 200 m from the interface (Vn200) and native vegetation at 400 m from the interface (Vn400).

Frequency of Individuals of Primary and Secondary Lepidopteran Pest Species

The most frequent primary pest species were *Stenalcidia grosica* Schaus, 1901, *Thyrinteina leucoceraea* Rindge, 1961 (Geometridae) and *O. vesulia*, while other important eucalyptus pests such as *S. caberata caberata*, *S. violascens* and *T. arnobia* had reduced frequencies. The frequencies of *S. grosica* and *T. leucoceraea* were greater in the eucalyptus at 400 and 200 m from the interface with 44.94% and 41.48% and 25.11% and 12.82% of the individuals collected, respectively. *Oxydia vesulia* in the native vegetation at 200 m from the interface had 33.33% of the individuals and *E. involuta* and *Eupseudosoma aberrans* Schaus, 1905 (Arctiidae) in the interface had 16.27% and 15.22%, respectively. *Automeris illustris* Walker, 1855 (Saturniidae) was the most frequent species of group II especially at the points inside the native vegetation at 400 and 200 m from the interface with 30.00% and 16.67% of the individuals collected for this group, respectively (Table 2).

Constancy of Primary and Secondary Lepidopteran Pest Species

Lepidopteran species were mainly constant at the interface, accessory at Eg200 and accidental at Eg400 and Bor (Table 3). No primary pest was constant at all points, but *S. grosica* was constant in the eucalyptus stand and at the inter-

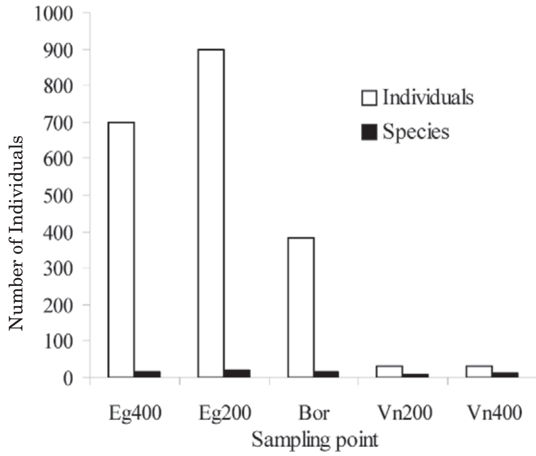

Fig. 1. Number of individuals and of species of lepidopteran primary and secondary pests of eucalyptus in Ipaba, Minas Gerais State, Brazil from Apr 1997 to Mar 1998. These points were designated as follows: eucalyptus at 400 m from the interface (Eg400), eucalyptus at 200 m from the interface (Eg200), interface of eucalyptus and native vegetation (Bor), native vegetation at 200 m from the interface (Vn200) and native vegetation at 400 m from the interface (Vn400).

face and accidental in the native vegetation; *T. leucoceraea* was constant in the eucalyptus, accessory at the interface and accidental inside the native vegetation; *Oxydia vesulia* was constant at the interface, accessory in the eucalyptus and accidental in the native vegetation; *Eupseudosoma aberrans* was constant at the interface, accidental in the eucalyptus and it was trapped in the native vegetation. Of the secondary pest species, *Idalus admirabilis* Cramer, 1777 (Arctiidae) was accessory in the eucalyptus and at the interface, while other species were accidental in the eucalyptus plantation and in the native vegetation (Table 3).

Discussion

The distribution of frequencies of lepidopteran pests of *E. grandis* was not uniform with a few species making up the majority of individuals collected. This shows the adaptability of lepidopterans pests in the eucalyptus plantation in Ipaba. *Stenalcidia grosica* represented 39.82% of the individuals of primary and secondary pests from Jun 1989 to Jun 1994 in *Eucalyptus urophylla* S. T. Blake (Myrtaceae) plantations in São José dos Campos, São Paulo State, Brazil (Pereira et al. 2001). This defoliator was also a primary and abundant pest from Aug 1991 to 1996 in *E. grandis* in Nova Era, Minas Gerais State, Brazil (Freitas et al. 2005) and from Jun 1993 to Jul 1998 in older (6 and 7 years) *E. grandis* plants in drier periods in Santa Bárbara, Minas Gerais State, Brazil (Guedes et al. 2000). This could been seen in the constant population size of this insect with the largest number of individuals during dry and cold periods from Jul 1992 to Jun 1993 on *E. urophylla* in Três Marias, Minas Gerais State, Brazil (Zanuncio et al. 2003). The increase of food in these plantations may favor adapted herbivores in detriment of their natural enemies, which can increase the damage (Zanuncio et al. 2006). Moreover, herbivores collected have more difficulties to find and colonize host plants in heterogeneous environments, where the food can be scarcer and the survival and the persistence of natural enemies greater (Zanuncio et al. 1998a).

The larger number of individuals collected in *E. grandis* compared to the native vegetation of the Atlantic Rainforest can be explained by the fact most organisms have greater number of species with lower populations in environments with low heterogeneity (Zanuncio et al. 1998a). The population of *O. vesulia* was greater from Jun 1993 to Jul 1998 in a *E. grandis* than in native plants of the Cerrado (Brazilian Savanna-type vegetation) biome in Paraopeba, Minas Gerais State, Brazil; also, the number of individuals of this species decreased between Feb and Aug during a period of lower rainfall and temperatures (Guedes et al. 2000). *Trichogramma acacioi* Brun, Moraes and Soares, 1984 (Hymenoptera: Trichogrammatidae) parasitized more than 93% of the eggs of this defoliator in the laboratory (Oliveira et al. 2011) and the predatory wasps *Champs* sp. (Hymenoptera: Ichneumonidae) preyed its larvae in São Paulo State, Brazil (Fernandes et al. 2010).

Thyrinteina leucoceraea was the second most collected species with 16.18% of the individuals of primary pests. This species causes economic damage as the main defoliator of eucalyptus in Brazil (Oliveira et al. 2005; Bernadino et al. 2007), even though its pupae were parasitized by *Palmistichus elaeisis* Delvare and LaSalle, 1993 (Hymenoptera: Eulophidae) on *E. urophylla* plants (Pereira et al. 2008). Outbreaks of lepidopteran defoliators can occur in eucalypt plantations but the presence of essential oils and secondary metabolites of these plants can help reduce their populations. This is why it is important to study the occurrence of these defoliators by eucalypt species and region (Henery 2011).

Thyrinteina arnobia and *Glena* sp. (Geometridae) were captured in low numbers, with 13 and 16 individuals, respectively during the entire period. Also, *Glena unipennaria unipennaria* Guenée, 1857 (Geometridae) was abundant from Aug 1991 to Jul 1996 and from Jun 1993 to Jul 1998 on *E. grandis* in Nova Era and Santa Bárbara, Minas Gerais State, Brazil, respectively. The number of individuals of this lepidopteran was greater on older plants (6 to 7 years old). This demonstrates the necessity of sampling pests during the entire life cycle of the eucalyptus plantation (Guedes et al. 2000; Freitas et al. 2005). *Thyrinteina arno-*

TABLE 2. FREQUENCY (%) OF INDIVIDUALS OF PRIMARY AND SECONDARY LEPIDOPTERAN PEST SPECIES IN THE EUCALYPT MONOCULTURE AND THE NATIVE VEGETATION AT EACH SAMPLING POINT IN IPABA, MINAS GERAIS STATE, BRAZIL FROM APR 1997 TO MAR 1998.

Family	Species	Group	Eg400	Eg200	Bor	Vn200	Vn400
Arctiidae	*Eupseudosoma aberrans*	I	01.14	05.57	15.22	—	—
	Eupseudosoma involuta	I	01.86	05.24	16.27	—	03.33
	Idalus admirabilis	II	05.42	07.92	06.30	—	03.33
Geometridae	*Glena bipennaria bipennaria*	I	03.00	04.36	03.67	03.33	03.33
	Glena sp.	I	01.28	00.33	01.05	—	—
	Iridopsis syrniaria	II	03.57	01.78	02.10	03.33	—
	Oxydia vesulia	I	10.13	13.04	09.98	33.33	16.67
	Sabulodes caberata caberata	I	—	—	00.26	00.33	—
	Stenalcidia grosica	I	44.94	41.48	29.40	26.68	16.67
	Thyrinteina arnobia	I	00.71	00.78	—	03.33	—
	Thyrinteina leucoceraea	I	25.11	12.82	08.66	06.67	13.33
Lymantriidae	*Sarsina violascens*	I	00.86	02.12	02.36	—	03.33
Notodontidae	*Blera varana*	I	00.28	00.33	—	—	—
	Misogada blerura	I	00.43	02.68	02.10	03.33	—
	Nystalea nyseus	I	00.28	—	00.26	—	03.33
Saturniidae	*Automeris illustris*	II	00.28	00.22	01.05	16.67	30.00
	Automeris melanops	II	—	00.11	00.53	—	—
	Eacles ducalis	II	—	00.22	00.53	—	—
	Eacles imperialis magnifica	II	—	00.22	—	—	—
	Hyperchiria incisa	II	00.71	00.56	—	—	06.68
	Lonomia faleata	II	—	—	00.26	—	—
Stenomatidae	*Timocratica palpalis*	II	—	00.22	—	—	03.33

The sampling points were designated as follows: eucalyptus at 400m from the interface (Eg400), eucalyptus at 200 m from the interface (Eg200), interface of eucalyptus and native vegetation (Bor), native vegetation at 200 m from the interface (Vn200) and native vegetation at 400 m from the interface (Vn400).

— The species was not collected.

bia and *Stenalcidia* spp. (Geometridae) showed greater numbers of individuals of the primary pests during periods of lower rainfall and temperature. *Psorocampa denticulata* Schaus, 1901 (Notodontidae) was more frequent in months with greater rainfall between Mar 1987 and Feb 1992 in *E. grandis* plantations in Bom Despacho, Minas Gerais State, Brazil (Zanuncio et al. 2006). This indicates the necessity of monitoring lepidopteran pests during these periods. *Podisus distinctus* Stäl, 1860, *Podisus nigrispinus* Dallas, 1851 (Heteroptera: Pentatomidae) (predators) and *P. elaeisis* (parasitoid) are natural enemies of *T. arnobia* on Myrtaceae (Soares et al. 2009; Oliveira et al. 2011; Pereira et al. 2011), especially on native plants, such as *Psidium guajava* L., 1753 and *Myrciaria cauliflora* (Mart.) O. Berg., 1854 when compared to exotic species such as *Eucalyptus* spp. (Grosman et al. 2005). Lepidopteran pests should be monitored during the entire growing cycle of the eucalypt culture to inform efforts to reduce damage by these insects (Wingfield et al. 2008). *Thyrinteina arnobia* had the highest number of individuals for all lepidopteran pests from Mar 1987 to Feb 1992 during an outbreak on *E. grandis* in Bom Despacho, Minas Gerais State, Brazil and preferred older plants (Zanuncio et al. 2006).

Eupseudosoma aberrans and *S. grosica* were not collected in this region but in Três Marias, Minas Gerais State, Brazil, they were consistently present in all collections and with high possibilities of outbreaks during Jul 1992 to Jun 1993 on *E. urophylla* (Zanuncio et al. 2003). Monitoring of lepidopteran defoliators in forest plantations and native vegetation has shown that species with longer wing spans are more frequent in areas of native vegetation, but the reasons for this are not known (Uehara-Prado et al. 2005).

The high number of individuals of primary and secondary pest species inside the *E. grandis* stand may have been caused by the greater food availability, and by the lower populations of natural enemies in the plantations in this area (Jäkel & Roth 2004; Sousa et al. 2010). This suggests greater possibilities of outbreaks of these species in Ipaba, Minas Gerais State, Brazil. The numbers of individuals of species of groups I and II were greater as shown by the temporal distribution in periods of lower temperature and relative humidity when plants may show stress mainly caused by water deficit. This stress may reduce defense mechanisms

TABLE 3. CONSTANCY OF PRIMARY AND SECONDARY LEPIDOPTERAN PEST SPECIES IN THE EUCALYPT MONOCULTURE AND THE NATIVE VEGETATION AT EACH SAMPLING POINT IN IPABA, MINAS GERAIS STATE, BRAZIL FROM APR 1997 TO MAR 1998.

Family	Species	Grupo	Eg400	Eg200	Bor	Vn200	Vn400
Arctiidae	*Eupseudosoma aberrans*	I	z	z	**W**	—	—
	Eupseudosoma involuta	I	z	**Y**	z	—	z
	Idalus admirabilis	II	**Y**	**Y**	**Y**	—	z
Geometridae	*Glena bipennaria bipennaria*	I	**Y**	**Y**	**Y**	z	—
	Glena sp.	I	z	z	z	—	—
	Iridopsis syrniaria	II	z	z	z	z	—
	Oxydia vesulia	I	**Y**	**Y**	**W**	z	z
	Sabulodes caberata caberata	I	—	—	z	z	—
	Stenalcidia grosica	I	**W**	**W**	**W**	z	z
	Thyrinteina arnobia	I	z	z	—	z	—
	Thyrinteina leucoceraea	I	**W**	**W**	**Y**	z	z
Lymantriidae	*Sarsina violascens*	I	z	y	z	—	z
Notodontidae	*Blera varana*	I	z	z	—	—	—
	Misogada blerura	I	z	**Y**	z	z	—
	Nystalea nyseus	I	z	—	z	—	z
Saturniidae	*Automeris illustris*	II	z	z	z	z	z
	Automeris melanops	II	—	z	z	—	—
	Eacles ducalis	II	—	z	z	—	—
	Eacles imperialis magnifica	II	—	z	—	—	—
	Hyperchiria incisa	II	z	z	—	—	z
	Lonomia faleata	II	—	—	z	—	—
Stenomatidae	*Timocratica palpalis*	II	—	z	—	—	z

The sampling points were designated as follows: eucalyptus at 400 m from the interface (Eg400), eucalyptus at 200 m from the interface (Eg200), interface of eucalyptus and native vegetation (Bor), native vegetation at 200 m from the interface (Vn200) and native vegetation at 400 m from the interface (Vn400).

W = constant species; **Y** = accessory species; z = accidental species; — the species was not collected.

and facilitate the survival of pests in eucalypt plantations. In addition under these conditions, processes of plant defense, such as the levels of compounds that reduce the digestibility of toxins by herbivores and release of allelochemicals to attract natural enemies are reduced (Zanuncio et al. 2006).

The high number of these pest species in eucalyptus plantations may be caused by the exotic Myrtaceae, which may not have developed defensive mechanisms to resist lepidopteran defoliators unlike the native plants of this family (Marinho et al. 2008). This is also caused by the greater species richness of areas with native vegetation (Rao et al. 2000; Barbosa et al. 2005). Homogeneous eucalyptus plantations have a larger food supply for pests and support fewer natural enemies of some pest species, which can result in increased populations of these pests (Steinbauer et al. 2006; Berndt & Allen 2010). Also, increased vegetation heterogeneity and ecological succession in plantations after they become 3 years old may be caused by lower levels of silvicultural activities in older stands. These activities may favor reproduction of many lepidopteran species and result in an increase in the diversity of insects present including natural enemies of pest species (Zanuncio et al. 1998b). The presence of immature individuals of lepidopteran primary or secondary pests in areas of native and cultivated forests is correlated to the numbers of adults of these insects captured with light traps (Hawes et al. 2009). The apparent species richness in the native forest and in its edge is probably caused by the confluence of these 2 habitats and the capture of insects from both habitats in the edge environment. Also, the light traps in these areas are in more open areas, and can attract insects from longer distances (Axmacher et al. 2004; Cunningham et al. 2005). Diversity of lepidopteran species of groups III (unimportant species with respect to eucalyptus) and IV (unidentified species) increased with the age of *E. grandis* plants from Mar 1987 to Feb 1992 in Bom Despacho, Minas Gerais State, Brazil (Zanuncio et al. 2006). The high occurrence of lepidopteran species in the *E. grandis* plantation may be explained by their dependence on food provided by eucalypt plants (Uehara-Prado et al. 2007). These factors can explain the greater number of individuals of insect pests in the eucalypt area and also indicates the diversity of lepidopterans may be used as indicator of ecosystems modification (Myers et al. 2000).

The primary pests, *E. involuta* and *O. vesulia*, were accidental in the *E. grandis* plantation, and the first was accessory in eucalyptus, suggesting it reaches peak population levels, which are short-lived. This variation can be caused by climate, natural enemies and by plant or insects factors. None of the species collected was constant or accessory in the native vegetation which may be caused by the larger plant heterogeneity and more stable insect populations (Rao et al. 2000; Jäkel & Roth 2004). The greatest number of species with fluctuating populations probably occurred because some of them were present in excessive numbers, which reduces the dominance of other potentially dominant species. The dominance index takes the number of insects collected into consideration (Bernardi et al. 2011). Species with populations that do not fluctuate can cause the appearance or disappearance of other organisms. This can occur during eucalyptus cultivation, where dominant insect species can increase their populations because of the available food supply, which explains outbreaks of lepidopteran pests in eucalypt plantations (Bernardi et al. 2008).

Of group II species, *I. admirabilis* showed greater abundance at point Eg200 and with 38 and 24 individuals at Eg400 and Bor, respectively, although it was accessory in these areas. Species of group II are important because they affect the diversity of ecosystems because of their high species diversity in ecological systems during succession (Bernardi et al. 2011). A high percentage of accidental species in forest communities indicates a more stable environment, while species listed as accessory are better adapted to the communities (Bernardi et al. 2011).

The number of individuals of lepidopteran pest species was low in the native vegetation fragment, which is more spatially heterogeneous and abundant in host plants than eucalypt plantations. The maintenance of these native vegetation areas inserted within the monoculture of eucalyptus and the vegetation under these trees can improve spatial heterogeneity and contribute to larger species diversity and natural biological control of herbivorous insects in reforestation with eucalyptus species.

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