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Authors: Zanuncio, José Cola, Vinha, Germano Lopes, Ribeiro, Rafael Coelho, Fernandes, Bianca Vique, Kassab, Samir Oliveira, et al.

Source: Florida Entomologist, 98(3) : 1003-1005

Published By: Florida Entomological Society

URL: <https://doi.org/10.1653/024.098.0338>

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Psorocampa denticulata (Lepidoptera: Notodontidae) pupae as an alternative host for *Palmistichus elaeisis* (Hymenoptera: Eulophidae)

José Cola Zanuncio¹, Germano Lopes Vinha¹, Rafael Coelho Ribeiro², Bianca Vique Fernandes³, Samir Oliveira Kassab⁴, Carlos Frederico Wilcken⁵, and Teresinha Vinha Zanuncio⁶

The parasitoid *Palmistichus elaeisis* Delvare & LaSalle (Hymenoptera: Eulophidae) has potential for biological control (Pereira et al. 2010a) because it has been found parasitizing the pupae of lepidopteran defoliators of *Eucalyptus* species (Myrtales: Myrtaceae) in Brazil including *Eupseudosoma involuta* Sepp (Arctiidae), *Euselasia eucerus* Hewitson (Riodinidae), *Sabulodes* sp. (Geometridae), *Dirphia moderata* Bouvier (Saturniidae), *Halysidota pearsoni* Watson (Arctiidae), *Hypsipyla grandella* Zeller (Pyrilidae), *Thyriniteina arnobia* Stoll (Geometridae), and *Thyriniteina leucocerae* Rindge (Geometridae) (Bittencourt & Berti Filho 1999; Pereira et al. 2008a,b, 2009; Zaché et al. 2013). In addition to these natural hosts, *P. elaeisis* can be reared on *Tenebrio molitor* L. (Coleoptera: Tenebrionidae) and *Bombyx mori* L. (Lepidoptera: Bombycidae) in the laboratory (Zanuncio et al. 2008; Pereira et al. 2009, 2010a).

Biological control programs with predators (Molina-Rugama et al. 1998; Torres et al. 1998) and parasitoids often rely on the availability of suitable alternative prey and hosts for economically mass rearing natural enemies (Zaviezo & Mills 2000). However, the nutritional requirements, size, age, and immune response of hosts may affect the quality of the natural enemies produced (Zanuncio et al. 1996; Silva-Torres et al. 2009; Andrade et al. 2010).

Psorocampa denticulata Schaus (Lepidoptera: Notodontidae) is a pest in *Eucalyptus* plantations in Brazil (Zanuncio et al. 2003). This species is a potential host for rearing parasitoids of lepidopteran defoliators of *Eucalyptus* species because its pre-pupae can be collected in large numbers from the soil around eucalyptus trees in areas with outbreaks of this insect (Guedes et al. 2000). Pre-pupae of *P. denticulata* are readily available in the soil for up to 6 mo until the onset of the rainy season, when its adults emerge. The pre-pupae of this insect can be stored, which suggests the possibility of using them as alternative host for mass rearing the parasitoid *P. elaeisis* during the dry period, when the populations of lepidopteran defoliators of eucalyptus are high and cause economic damage (Zanuncio et al. 1998). Therefore, the aim of this study was to evaluate the possibility of using *P. denticulata* as an alternative host for rearing the parasitoid *P. elaeisis* in the laboratory or in a mass-rearing facility.

This study was conducted in the Laboratory of Biological Control of Insects (LCBI) of the Institute of Biotechnology Applied to Agriculture (BIOAGRO) of the “Universidade Federal de Viçosa (UFV)” in Viçosa, Minas Gerais State, Brazil. The pre-pupae of *P. denticulata* were collected in a *Eucalyptus* plantation in Sete Lagoas, Minas Gerais State, Brazil, stored in cloth bags, and transported to the laboratory, where they were held in plastic trays with sterilized soil at 25 ± 1 °C, $70 \pm 10\%$ RH, and a 12:12 h L:D photoperiod until pupation.

Thirty *P. denticulata* pupae, in total, were placed individually in test tubes plugged with cotton wool. Next, twenty 72-h-old *P. elaeisis* females were placed per glass tube (14 × 2.2 cm) with one 24-h-old *P. denticulata* pupa (biomass of 787.40 ± 78.29 mg). The parasitoids were fed with drops of honey every 48 h (Pereira et al. 2009). After this period, the *P. denticulata* pupae were transferred to other glass tubes (14 × 2.2 cm) to observe the emergence of the parasitoid progeny or of the lepidopteran adults.

The percentages of parasitism and emergence, the duration of the life cycle (egg to adult), and the number of *P. elaeisis* progeny per *P. denticulata* pupa were recorded. Also, the body length (distance from the front of the head to the tip of the abdomen) and the head capsule width (distance between the eyes) of 90 males and 180 females of *P. elaeisis* that emerged from the *P. denticulata* pupae were measured. The measurements were made with an ocular micrometer installed in a stereomicroscope (Pereira et al. 2010b).

Results showed that parasitism and emergence rates of the progeny of *P. elaeisis* were 100 and 90%, respectively, from the host pupae parasitized; the egg-to-adult period was 22.22 ± 0.49 d; and 734.55 ± 54.56 *P. elaeisis* individuals emerged per *P. denticulata* pupa. Each *P. denticulata* pupa produced more parasitoid progeny than those of alternative hosts such as *B. mori*, *Diatraea saccharalis* F. sensu Guenée (Lepidoptera: Crambidae), and *Anticarsia gemmatalis* Hübner, *Heliothis virescens* F., and *Spodoptera frugiperda* Smith & Abbot (Lepidoptera: Noctuidae) (Bittencourt & Filho Berti 1999; Pereira et al. 2010b).

Psorocampa denticulata pupae have the attributes to serve as a more suitable host to mass rear *P. elaeisis* than other host species such as *T. arnobia* and *T. leucocerae* (Pereira et al. 2008a). These attri-

¹Departamento de Entomologia, Universidade Federal de Viçosa, 36570-900, Viçosa, Minas Gerais, Brasil

²Departamento de Fitotecnia, Universidade Federal de Viçosa, 36570-900, Viçosa, Minas Gerais, Brasil

³Vallourec & Mannesmann Florestal Ltda, Centro de Apoio a Pesquisa e Desenvolvimento Florestal, 35774-000, Paraopeba, Minas Gerais, Brasil

⁴Faculdade de Ciências Agrárias, Universidade Federal da Grande Dourados, 79804-970, Dourados, Mato Grosso do Sul, Brasil

⁵Departamento de Proteção Vegetal, Faculdade de Ciências Agrônômicas, 18610-307, Botucatu, São Paulo, Brasil

⁶Sociedade de Investigações Florestais, Universidade Federal de Viçosa, 35570-900, Viçosa, Minas Gerais, Brasil

*Corresponding author; E-mail: zanuncio@ufv.br

butes may include superior nutritional value (Zaviezo & Mills 2000) and larger body size (Brodeur & Boivin 2004). The duration of the *P. elaeisis* life cycle within *P. denticulata* pupae and other alternative hosts (i.e., *T. molitor* [Zanuncio et al. 2008]) were similar. The greater progeny of *P. elaeisis* per host could be related to the better nutritional quality and higher biomass of the *P. denticulata* pupa, such as observed for the *B. mori* pupa (Pereira et al. 2009). Furthermore, the larger body of *P. denticulata* has more resources for the immature of this parasitoid as was found in the parasitoid *Apanteles galleriae* Wilkinson (Hymenoptera: Braconidae) (Uçkan et al. 2004). The body length of *P. elaeisis* females and males that emerged from *P. denticulata* pupae was 1.94 ± 0.039 mm and 1.50 ± 0.022 mm, respectively, and the width of the head capsule was 0.48 ± 0.530 mm and 0.39 ± 0.011 mm, respectively. These results were similar to those of *P. elaeisis* reared on *A. gemmatalis* and *B. mori* pupae, which were considered suitable hosts for this parasitoid (Pereira et al. 2010b). The size of the body and the width of the head capsule of parasitoids and predators were positively correlated with reproductive traits such as fecundity, sex ratio, and the number and longevity of the offspring (Sagarra et al. 2001; Oliveira et al. 2003; Moreira et al. 2009).

This study showed that *P. elaeisis* can be reared on *P. denticulata* pupae as an alternative host to produce this parasitoid for release in biological control programs of lepidopteran pests of eucalyptus.

We thank “Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq),” “Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES),” and “Fundação de Amparo à Pesquisa do Estado de Minas Gerais (FAPEMIG)” for financial support. Global Edico Services edited and rewrote the English of this manuscript. We thank Jesusa C. Legaspi for revising the final version of this manuscript.

Summary

Psorocampa denticulata Schaus (Lepidoptera: Notodontidae) is a pest of *Eucalyptus* species (Myrtales: Myrtaceae) in Brazil. The pre-pupa stage of this species is present in the soil surrounding infested trees for up to 6 mo during the dry season and can be collected and stored in large numbers. The potential use of *P. denticulata* pupae as an alternative host for rearing the parasitoid *Palmistichus elaeisis* Delvare & LaSalle (Hymenoptera: Eulophidae) was tested in the laboratory. Up to 24-h-old *P. denticulata* pupae (787.40 ± 78.29 mg) were individually exposed to twenty 72-h-old *P. elaeisis* females for 48 h. These exposed pre-pupae were individually transferred to a glass tube for the emergence either of parasitoid progeny or of the adult lepidopteran. The parasitism and emergence rates of *P. elaeisis* from *P. denticulata* pupae were 100 and 90%, respectively. The life cycle (egg to adult) was 22.22 ± 0.49 days, and the number of progeny of this parasitoid was 734.55 ± 54.56 per host. We concluded that this generalist parasitoid could be mass reared on *P. denticulata* pupae and released as part of an integrated program to manage lepidopteran pests in eucalyptus plantations.

Key Words: biological control; *Eucalyptus*; mass rearing; parasitism

Sumário

Psorocampa denticulata Schaus (Lepidoptera: Notodontidae) tem sido relatada como praga de *Eucalyptus* spp. (Myrtales: Myrtaceae) no Brasil. Esta espécie tem um estágio de pré-pupa no solo por seis meses, durante a estação seca, e pode ser coletada e armazenada em grandes números. A possibilidade de utilização de pré-pupas de *P. denticulata* como hospedeiro alternativo para criação do parasitoide *Palmistichus elaeisis* Delvare & LaSalle (Hymenoptera: Eulophidae) foi avaliada em

laboratório. Pupas de *P. denticulata* ($787,40 \pm 78,29$ mg) com até 24 h de idade foram expostas individualmente a 20 fêmeas de *P. elaeisis*, com 72 h de idade, durante 48 horas. Estas pupas foram transferidas para tubos de vidro para obtenção da progênie desse parasitoide ou de adultos de *P. denticulata*. As taxas de parasitismo e emergência da progênie de *P. elaeisis* em pupas de *P. denticulata* foram de 100 e 90%, respectivamente. O ciclo de vida (ovo a adulto) foi de $22,22 \pm 0,49$ dias e o número de descendentes do parasitoide de $734,55 \pm 54,56$ por pupa hospedeira. O parasitoide generalista, *P. elaeisis*, pode ser criado com pupas de *P. denticulata* e ser liberado como parte do programa integrado para o manejo de lepidópteros praga em plantios de eucalipto.

Palavras Chave: controle biológico; criação massal; *Eucalyptus*; parasitismo

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