

Scientific Note

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Spodoptera cosmioides (Lepidoptera: Noctuidae) as an alternative host for mass rearing the parasitoid *Palmistichus elaeisis* (Hymenoptera: Eulophidae)

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Abstract: Different alternative hosts can reduce or even avoid pre-imaginal conditioning of parasitoids in mass production programs. *Spodoptera cosmioides* (Walker) (Lepidoptera: Noctuidae) may be an alternative host for mass rearing the parasitoid *Palmistichus elaeisis* Delvare & LaSalle (Hymenoptera: Eulophidae). The objective of this study was to evaluate the parasitism, emergence, egg-to-adult period, progeny size, sex ratio, and consumption of host tissue per individual of *P. elaeisis* produced using *S. cosmioides* pupae in the laboratory. Newly formed

S. cosmioides pupae were weighed, individualized in glass tubes and each one was exposed to six newly emerged *P. elaeisis* females during 48 h. These pupae were transferred to plastic pots until the emergence of *P. elaeisis* adults. *Palmistichus elaeisis* parasitized and emerged from 100.0 % and 87.5 % of the *S. cosmioides* pupae, respectively. The egg-to-adult period of *P. elaeisis* was 24.28 ± 0.18 days, with 109 ± 2 individuals emerging per host pupae. Mass consumption of the host was 2.56 ± 0.01 mg per parasitoid emerged. This is the first report of *P. elaeisis* parasitizing and developing in *S. cosmioides* pupae. The ease of rearing *S. cosmioides* with an artificial diet, and the high parasitism, emergence, and progeny size of *P. elaeisis* support the suitability of this alternative host to mass-rearing this parasitoid.

Keywords: biological control; insect increment; natural enemies

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Resumo: Diferentes hospedeiros alternativos podem reduzir ou, mesmo, evitar o condicionamento pré-imaginal de parasitoides em programas de produção em massa. *Spodoptera cosmioides* (Walker) (Lepidoptera: Noctuidae) pode ser um hospedeiro alternativo para a criação massal do parasitoide *Palmistichus elaeisis* Delvare & LaSalle (Hymenoptera: Eulophidae). O objetivo deste estudo foi avaliar o parasitismo, emergência, período ovo-adulto, tamanho da progênie, razão sexual, e consumo de tecido hospedeiro por indivíduo de *P. elaeisis* produzido a partir de pupas de *S. cosmioides* em laboratório. Pupas recém-formadas de *S. cosmioides* foram pesadas, individualizadas em tubos de vidro e cada uma delas foi exposta a seis fêmeas recém-emergidas de *P. elaeisis* por 48 horas. Essas pupas foram transferidas para potes plásticos até a emergência dos adultos de *P. elaeisis*. *Palmistichus elaeisis* parasitou e emergiu 100,0 % e 87,5 % das pupas de *S. cosmioides*, respectivamente. O período ovo-adulto de *P. elaeisis* foi de $24,28 \pm 0,18$ dias, com 109 ± 2 indivíduos emergidos por pupa

hospedeira. O consumo de massa do hospedeiro foi de $2,56 \pm 0,01$ mg por parasitoide emergido. Este é o primeiro relato de *P. elaeisis* parasitando e se desenvolvendo em pupas de *S. cosmioides* em laboratório. A facilidade de criação de *S. cosmioides* com dieta artificial e o alto parasitismo, emergência e tamanho da progênie de *P. elaeisis* aumentam a aptidão deste hospedeiro alternativo para a criação massal deste parasitoide.

Palavras Chave: controle biológico; incremento de insetos; inimigos naturais

Biological control with parasitoids is a component of integrated pest management (IPM) with potential to reduce pesticide use (Costa et al. 2020). The gregarious pupal endoparasitoid *Palmistichus elaeisis* Delvare & LaSalle (Hymenoptera: Eulophidae) is available in the Brazilian market with a reference specification (ER50 – Precedes the registration of a phytosanitary product with approved use in organic agriculture) from the Ministério da Agricultura, Pecuária e Abastecimento (MAPA) to manage lepidopteran pests (MAPA 2022). This natural enemy parasitized species of the Arctiidae, Bombycidae, Crambidae, Geometridae, Lymantriidae, Noctuidae, Nymphalidae, Papilionidae, Riodinidae, Saturniidae (Lepidoptera), and Tenebrionidae (Coleoptera) families (Da Silva Rolim et al. 2020; Martins et al. 2019; Rodríguez-Dimaté et al. 2016). Generalist behavior, easy rearing, high percentage parasitism and percentage emergence, and regulated market support the importance of the parasitoid *P. elaeisis* in IPM (De La Cruz et al. 2017).

Mass production and commercialization of parasitoids depend on the availability of suitable hosts (Tepa-Yotto et al. 2021). *Palmistichus elaeisis* is often reared on *Tenebrio molitor* (Linnaeus) (Coleoptera: Tenebrionidae) pupae in the laboratory (Martins et al. 2019). The choice of alternative hosts is important because it can reduce or even prevent the pre-imaginal conditioning of parasitoids when they lose the ability to recognize the chemical signals of the natural host (Ghaemmaghani et al. 2021; Moraes et al. 2023).

Spodoptera cosmioides caterpillars (Walker) (Lepidoptera: Noctuidae) feed on many cultivated or weed plants (Da Silva et al. 2017). This pest has a high leaf consumption rate, causing damage in many crops of economic importance, such as beans, coffee, cotton, eucalyptus, maize, rice, and soybean in Brazil (Lutz et al. 2018; Machado et al. 2020). Approximately 126 plants from 41 families are hosts for *S. cosmioides* (Paez Jerez et al. 2022). This insect can be reared using an artificial diet in the laboratory, allowing researchers to develop management strategies against this pest and to use its pupae to multiply natural enemies in biofactories (Da Silva et al. 2017).

Spodoptera cosmioides pupae may be an alternative host for mass-rearing parasitoids. The objective of this study was

to evaluate the parasitism, emergence, egg-to-adult period, progeny size, sex ratio, and consumption of host tissue per individual of *P. elaeisis* produced using *S. cosmioides* pupae in the laboratory.

The study was carried out at the Forest Entomology Laboratory (FEL) (18.2022 °S, 43.5715 °W) of the Universidade Federal dos Vales do Jequitinhonha e Mucuri (UFVJM) in Diamantina, Minas Gerais state, Brazil in an acclimatized room with temperature of 25 ± 1 °C, relative humidity of 70 ± 10 % and a photoperiod of 12 h L:D.

The insects were obtained from the rearing facility of the Laboratory of Biological Control of Insects (LBCI) at the UFVJM. *Palmistichus elaeisis* was reared in plastic pots (500 mL) with pupae (<24 h old) of the alternative host *Tenebrio molitor* Linnaeus (Coleoptera: Tenebrionidae) and the adults of this natural enemy were fed honey droplets. *Spodoptera cosmioides* caterpillars were reared in plastic pots (100 mL) using an artificial diet (Pantoja et al. 1987), and its adults were kept in cylindrical cages (50 × 20 cm) made of polyvinyl chloride (PVC) and provided with a solution of water, sugar, and ascorbic acid (Oliveira et al. 1990).

Ten newly formed pupae (<24 h) of *S. cosmioides* were weighed (280.40 ± 2.07 mg) on an analytical balance (accuracy of 0.01 g), individualized in glass tubes (14 × 2.2 cm) and exposed, each one, to six newly emerged *P. elaeisis* females for 48 h (Caldeira et al. 2022). Eight of these pupae were transferred to plastic pots (250 mL) until the emergence of *P. elaeisis* to collect biological data on this parasitoid. Five other non-parasitized *S. cosmioides* pupae were weighed before and after 48 h, and both masses were used to calculate their natural weight losses (0.16 ± 0.01 mg). The percentage of parasitism [(number of *S. cosmioides* pupae with parasitoid emergence + pupae without adult *S. cosmioides* emergence)/(total number of pupae) × 100] and emergence [(number of *S. cosmioides* pupae with parasitoid emergence)/(number of parasitized pupae) × 100], egg-to-adult period (days), progeny size (numbers of males + females), and sex ratio (females/males + females) of *P. elaeisis* and the consumption (mg) of biomass from *S. cosmioides* pupae per *P. elaeisis* individual produced were evaluated. The two remaining *S. cosmioides* pupae were opened with a stylet to observe the development stage of this parasitoid, one at 9 days and one at 18 days after parasitism by *P. elaeisis* (Figure 1A and B). Two adult specimens (one male and one female) of *P. elaeisis* that emerged were photographed (Figure 1C and D) with a camera Optika OPTIKAM B5 attached to a stereomicroscope with Optika Vision Lite 2.1 software.

Palmistichus elaeisis parasitized 100 % and emerged from 87.5 % of *S. cosmioides* pupae. The high percentage of parasitism and emergence of *P. elaeisis* in *S. cosmioides*

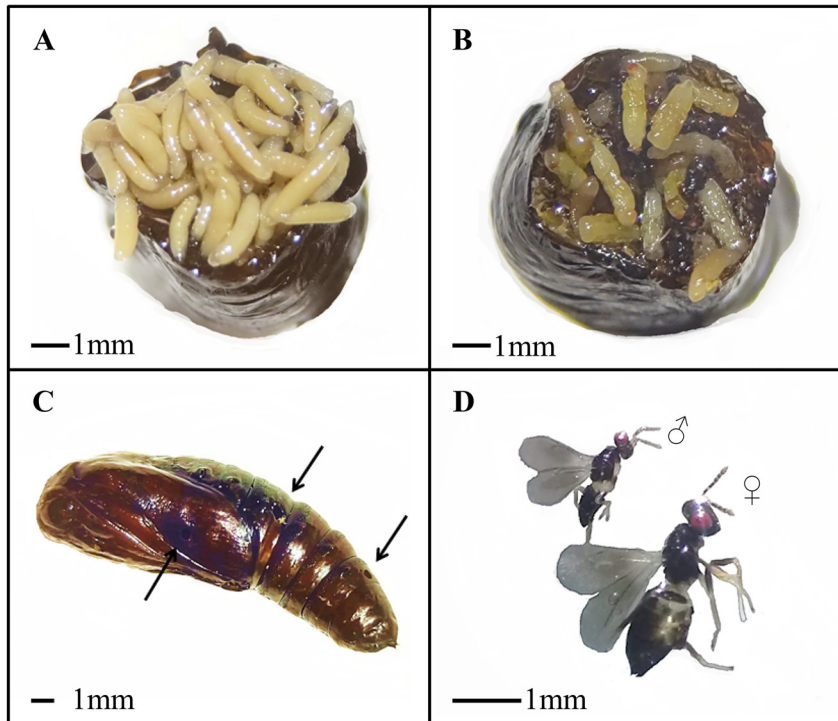


Figure 1: Larvae (A) and pupae (B) of *Palmistichus elaeisis* (Hymenoptera: Eulophidae) in pupae of *Spodoptera cosmioides* (Lepidoptera: Noctuidae), emergence holes of *P. elaeisis* (C) and adults (D) of *P. elaeisis*, male (♂) and female (♀), emerged from *S. cosmioides* pupae.

pupae was similar to that reported for this natural enemy in *Anticarsia gemmatilis* Hubner (Lepidoptera: Noctuidae) and *Bombyx mori* Linnaeus (Lepidoptera: Bombycidae) pupae with 100 % and 100 % parasitism and 85 % and 90 % emergence, respectively (De Sousa Pereira et al. 2018; Pereira et al. 2009). The parasitism of all *S. cosmioides* pupae and the high emergence of *P. elaeisis* confirm that the immune response is low and the quality of this host is adequate for the development of the parasitoid offspring.

The egg-adult period of *P. elaeisis* in *S. cosmioides* pupae was 24.28 ± 0.18 days, longer than that of this parasitoid in *A. gemmatilis*, *Diatraea saccharalis* (Fabricius) (Lepidoptera: Crambidae), *Heliothis virescens* (Fabricius) (Lepidoptera: Noctuidae), *Spodoptera frugiperda* (Smith) (Lepidoptera: Noctuidae), and *Thyrinitea arnobia* (Stoll) (Lepidoptera: Geometridae) with 18.9, 19.5, 22.0, 19.7, and 20.2 days, respectively (Martins et al. 2020). This may be related to the host species, diet, and weight affecting the development period of parasitoids (Rodríguez-Dimaté et al. 2016). The morphophysiological and nutritional properties of hosts must be adequate for the development of parasitoids that, when feeding, accumulate reserves to complete the immature stage (Tiago et al. 2019). The longer egg-adult period of parasitoids reduces the number of their generations (Badran et al. 2020) and, consequently, the numbers of individuals produced for biological control programs.

The progeny size of *P. elaeisis* emerged per *S. cosmioides* pupae was 109 ± 2 individuals. The progeny size of *P. elaeisis*

per *S. cosmioides* pupa was higher than that of this parasitoid in *T. molitor* pupae (69 ± 7), similar to that on *A. gemmatilis* (108 ± 17), and lower than that on *Methona themisto* (Hübner) (Lepidoptera: Nymphalidae) (138 ± 9), *Citioica anthonilis* (Herrich-Schaeffer) (Lepidoptera: Saturniidae) (286 ± 29), and *Heraclides anchisiades capys* (Hübner) (Lepidoptera: Papilionidae) (323 ± 38) pupae (Tavares et al. 2018). This is due to the size of the host pupa, with larger parasitoid progeny size in bigger pupae with more space and food available and reduced competition between their immatures (Iqbal et al. 2019). In addition, injection of toxins during multiple ovipositions by gregarious parasitoids, such as *P. elaeisis*, reduces or neutralizes the host's immune response (De Sousa Pereira et al. 2017) allowing the development of its offspring.

The sex ratio of *P. elaeisis* in *S. cosmioides* pupae was 0.85 ± 0.03 , similar to that of this parasitoid in *T. molitor* pupae (0.81 ± 0.02) (Martins et al. 2020). The high sex ratio of *P. elaeisis*, above 0.80, in *S. cosmioides* pupae is a characteristic of Eulophidae parasitoids (Caldeira et al. 2022). Females are responsible for parasitism and progeny production and the largest proportion of them is important for maintaining laboratory rearing, conducting experiments, and selection of individuals for release into the field (Camilo et al. 2016). The sex ratio of parasitoids above 0.50 increases their importance in the biological control of pests (Rossoni et al. 2016), following the quality control processes of natural enemies.

The biomass consumed from *S. cosmioides* pupae was 2.56 ± 0.01 mg per individual of *P. elaeisis* produced. The consumption of biomass from *S. cosmioides* per individual of *P. elaeisis* was higher than that of this parasitoid with pupae of *T. molitor* (1.35 ± 0.16) and *H. anchisiades* (1.32 ± 0.31), similar in those of *A. gemmatilis* (2.59 ± 0.43) and *C. anthonilis* (2.61 ± 0.62) and lower than in those of *M. themisto* (3.10 ± 0.42) (Tavares et al. 2018). Biomass consumption by parasitoids varies with host quality (Sanders et al. 2016). A maximum number of *P. elaeisis* should be produced with the lowest possible biomass of *S. cosmioides* pupae per individual of this parasitoid.

This is the first report of *P. elaeisis* parasitizing and successfully developing within *S. cosmioides* pupae. The ability to rear *S. cosmioides* with an artificial diet, along with the high parasitism, emergence, and offspring production of *P. elaeisis*, supports the suitability of this alternative host for the mass-rearing of this parasitoid.

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Research ethics: Not applicable.

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Data availability: The raw data can be obtained on request from the author Wilson Faustino Júnior (wilson.faustino@ufvjm.edu.br).

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