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Phytophagy on eucalyptus plants increases the development and reproduction of the predator *Podisus nigrispinus* (Hemiptera: Pentatomidae)

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ABSTRACT. The effect of plant feeding on biological aspects of *Podisus nigrispinus* (Dallas) (Heteroptera: Pentatomidae) was evaluated. Nymphs and adults of this predator were fed with *Tenebrio molitor* L. (Coleoptera: Tenebrionidae) pupae on *Eucalyptus urophylla* plants in the field or only with pupae of this prey in the laboratory. The development and nymphal survival, as well as the pre-oviposition period, number of egg masses, number, fertility and viability of eggs and the longevity of females of this predator were evaluated. The eucalyptus plants improved the development of *P. nigrispinus*. This demonstrates that this predator can present higher population growth with eucalyptus plants and *T. molitor* pupae than in the laboratory (controlled conditions) only with this prey. These plants can supply nutrients that can the population growth and efficiency of *P. nigrispinus* for biological control in eucalyptus plantations.

Keywords: *Podisus nigrispinus*, biological control, feeding habit, vegetable supplement, predator.

RESUMO. Fitofagia em plantas de eucaliptos aumenta o desenvolvimento e a reprodução do predador *Podisus nigrispinus* (Hemiptera: Pentatomidae). O efeito da alimentação em plantas sobre os aspectos biológicos de *Podisus nigrispinus* (Hemiptera: Pentatomidae) foi avaliado. Ninfas e adultos desse predador foram alimentados com pupas de *Tenebrio molitor* L. (Coleotpera: Tenebrionidae) em plantas de *Eucalyptus urophylla* no campo ou, apenas, em laboratório. O desenvolvimento e a sobrevivência ninfal desse predador, além do período de pré-oviposição, número de posturas, viabilidade dos ovos e a fertilidade e longevidade de fêmeas foram avaliados. A planta de eucalipto proporcionou um incremento no desenvolvimento de *P. nigrispinus*. Isto demonstra que esse predador pode apresentar maior crescimento populacional com plantas de eucalipto e pupas de *T. molitor* alimentado com apenas a presa (condições controladas). A planta pode fornecer nutrientes que aumentam o crescimento populacional e a eficiência de *P. nigrispinus* para o controle biológico em plantios de eucalipto.

Palavras-chave: *Podisus nigrispinus*, controle biologico, hábito alimentar, suplemento vegetal, predador.

Introduction

The high quantity and low quality of resources in agricultural and forest monocultures can favor a few species that can cause aesthetic, ecological or economical problems in these ecosystems (ZANUNCIO et al., 2000). However, natural enemies can affect the population dynamics of these insects (PEREIRA et al., 2008).

The release of predator insects in agricultural and forest systems represents a critical stage to biological control programs (SILVA et al., 2009), because adverse conditions such as prey shortage can affect their reproductive potential and efficiency (WESTICH; HOUGH-GOLDSTEIN, 2001). The predatory stinkbug, *Podisus nigrispinus* (Dallas) (Hemiptera: Pentatomidae), is found across South America to Central America (RODRIGUES et al., 2008). This insect preys on over 30 insect lepdopteran pests (RODRIGUES et al., 2008).

For over a decade, forest companies in Minas Gerais State, Southeast Brazil, have used an advanced and economical mass production system to raise *Podisus nigrispinus* (Dallas) (Hemiptera: Pentatomidae) for augmentative releases to help protect eucalyptus plots predisposed to caterpillar attacks. More than five million predators have been

released, resulting in significant reductions in insecticide use to control lepidopteran larvae (NEVES et al., 2009).

However, predators of the family Pentatomidae can feed on host plants of their preys without damaging them (AZEVEDO et al., 2007), which can partially compensate adverse situations including prey shortage (ASSIS JÚNIOR et al., 1999). Species of the *Brontocoris tabidus* Signoret (Hemiptera: Pentatomidae) showed higher weight, oviposition rate and longevity with *Tenebrio molitor* L. (Coleoptera Tenebrionidae) and *E. urophylla* seedlings than only with this prey (ZANUNCIO et al., 2000), and *Supputius cincticeps* (Stål) (Hemiptera: Pentatomidae) had higher reproductive rate with prey and *E. urophylla* (ASSIS JÚNIOR et al., 1999). This research is necessary because prey shortage (MOLINA-RUGAMA et al., 1998) and rearing under field conditions with vegetable material (ZANUNCIO et al., 2004) can affect the life cycle and the efficiency of Pentatomidae predators (MOHAGHEGH et al., 1999).

The objective was to study biological aspects of the predator *Podisus nigrispinus* (Dallas) (Hemiptera Pentatomidae) with *T. molitor* pupae on *E. urophylla* plants in the field or only with this prey in the laboratory.

Material and methods

This research was developed at the Federal University of Viçosa (UFV), in the municipality of Viçosa, Minas Gerais State, Brazil, with *P. nigrispinus* on *E. urophylla* plants and *T. molitor* pupae in the field or only with this prey in the laboratory. First instar nymphs of *P. nigrispinus* were obtained from egg masses of the mass rearing facility of the Laboratory of Forest Entomology of the Department of Animal Biology at UFV, where this predator is reared under temperature of 25 ± 2°C, 70 ± 10% of relative humidity and photoperiod of 12 hours. These nymphs were divided in two groups. The first was maintained in the laboratory in controlled conditions (as described above) in Petri dishes (15 x 1.2 cm) with one *T. molitor* pupae, daily, as prey. A total of 20 Petri dishes were used with 10 nymphs of *P. nigrispinus* each. The second group was reared in groups of 10 nymphs per gauze bag (30 x 20 cm) with 20 bags involving *E. urophylla* branches in the field and fed, daily, with *T. molitor* pupae (ZANUNCIO et al., 2004). The duration and mortality of each instar were daily observed for both groups of nymphs.

Adults of *P. nigrispinus* obtained in each group (laboratory and field) were weight in a scale with a precision of 0.1 mg and sexed based on the genitalia and size of their body. A total of ten pairs of *P. nigrispinus* were formed per group. The first continued to receive *T. molitor* pupae in Petri dish (15 x 1.2 cm) in the laboratory with 10 dishes with a pair of *P. nigrispinus* each. The individuals of the second group were put in 10 organza bags (as described above) (a pair per bag) involving *E. urophylla* branches and they received *T. molitor* pupae daily. The climatic conditions (June 12 to September 19, 2002), registered by the Department of Agricultural Engineering of UFV were temperature of 18.39 ± 0.17°C, relative humidity of 75.01 ± 0.73% and accumulated rainfall of 0.37 ± 0.22 mm.

The pre-oviposition period, numbers of egg masses and eggs, as well as the longevity of females of *P. nigrispinus* were observed daily. The egg masses of this predator were removed from the gauze bags and put in Petri dishes (9.0 x 1.2 cm) with a moistened cotton wad and taken to the laboratory (25 ± 2°C; 75 ± 10% R.H.; 12 photoperiod) to obtain the fertility and viability of eggs per female of *P. nigrispinus*. These data were subjected to the Mann-Whitney test at 5% probability.

Results and discussion

The duration of most instars of *P. nigrispinus* was longer with *T. molitor* pupae in eucalyptus plants than in the laboratory with *T. molitor* pupae ($p < 0.05$). However, the duration of the third instar was longer for nymphs of this predator in the laboratory (Figure 1A).

The accumulated survival of *P. nigrispinus* from the first to the fourth instar was, approximately, 95% with *T. molitor* pupae on eucalyptus plants and in the laboratory only with *T. molitor* pupae (Figure 1B). However, the survival of the fifth instar was around 80% for this predator in the laboratory with *T. molitor* pupae (Figure 1B).

The period of pre-oviposition of *P. nigrispinus* was longer in the field ($p < 0.05$) (Figure 2), with around 16 days with *T. molitor* on eucalyptus plants and 3.16 days in laboratory with pupae of this prey. The number of eggs per egg mass was similar for both groups, but that of egg masses was higher for females of *P. nigrispinus* in the field than in the laboratory ($p < 0.05$) (Figure 3).

The percentage of fertile and viable eggs of *P. nigrispinus* was higher with *T. molitor* on eucalyptus

plants than in the laboratory with this prey ($p < 0.05$) (Figure 4A and B). The survival of *P. nigrispinus* was also higher with *T. molitor* pupae on eucalyptus plants than in the laboratory with this prey (Figure 5).

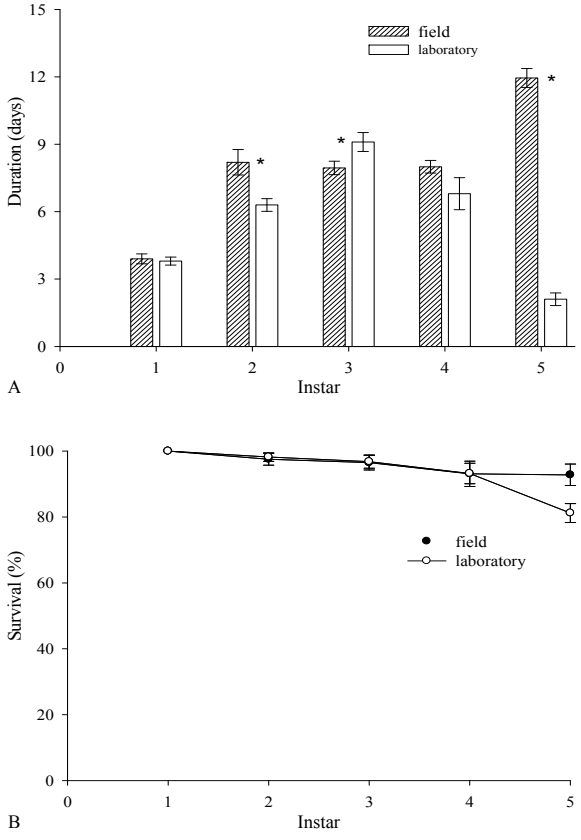

Figure 1. Duration in days (±standard error) of each instar (A) and average of survival % (±standard error) (B) of nymphs of *Podisus nigrispinus* (Hemiptera: Pentatomidae) on *Eucalyptus urophylla* plants and *Tenebrio molitor* (Coleoptera: Tenebrionidae) pupae or only with pupae of this prey in the laboratory. Means followed by (*) per instar differ between them by the Mann-Whitney test at 5% probability.

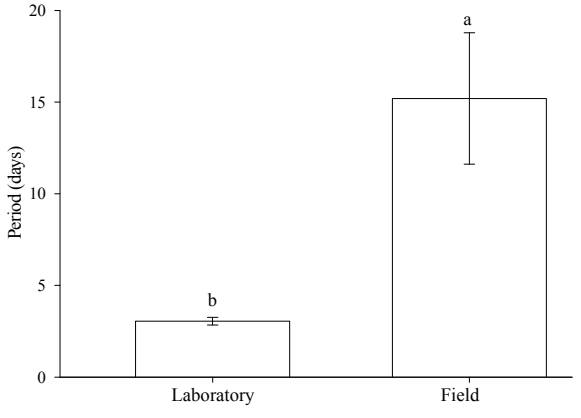

Figure 2. Pre-oviposition period (±standard error) of *Podisus nigrispinus* (Hemiptera: Pentatomidae) on the field in *Eucalyptus urophylla* plants and *Tenebrio molitor* (Coleoptera: Tenebrionidae) pupae or only pupae of this prey in the laboratory ($p < 0.05$).

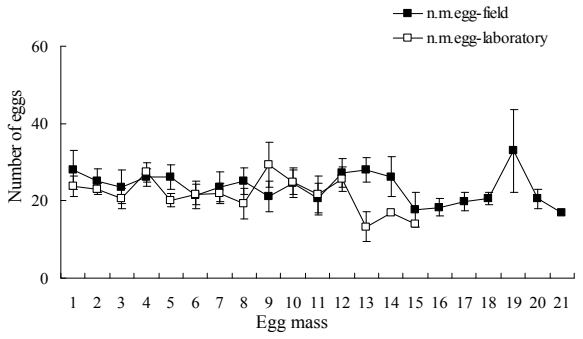

Figure 3. Number of eggs per egg mass (±standard error) of *Podisus nigrispinus* (Hemiptera: Pentatomidae) on the field in *Eucalyptus urophylla* plants and *Tenebrio molitor* (Coleoptera: Tenebrionidae) pupae or only pupae of this prey in the laboratory ($p < 0.05$).

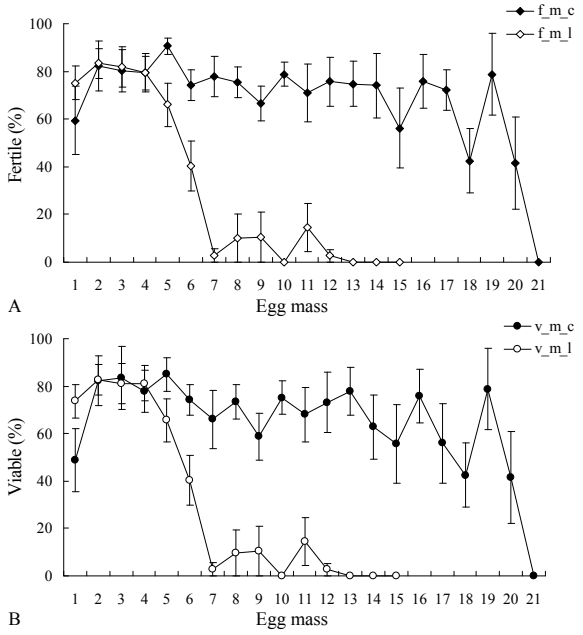

Figure 4. Percentage of fertile (±standard error) (A) and viable eggs per egg mass (±standard error) (B) of *Podisus nigrispinus* (Hemiptera: Pentatomidae) on the field in *Eucalyptus urophylla* plants and *Tenebrio molitor* (Coleoptera: Tenebrionidae) pupae or, only, pupae of this prey in the laboratory ($p < 0.05$). (f_m_c: average fertility in the field; f_m_l: average fertility in the laboratory; v_m_c: average egg viability in the field; v_m_l: average egg viability in the laboratory).

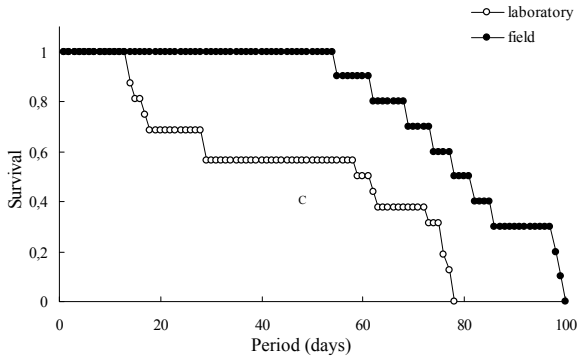

Figure 5. Survival of adults of *Podisus nigrispinus* (Hemiptera: Pentatomidae) in the field on *Eucalyptus urophylla* plants and *Tenebrio molitor* (Coleoptera: Tenebrionidae) pupae or only pupae of this prey in the laboratory ($p < 0.05$).

The longer nymph and pre-oviposition periods of *P. nigrispinus* in the field can also be due to the lower temperature in these conditions. Abiotic factors such as temperature, relative humidity and rainfall affected the development but not the survival of *P. nigrispinus* nymphs. The vegetable material showed a positive effect even in adverse situations, and thus it represents an alternative food source in the laboratory and in the field, especially during periods of shortage or absence of prey (LEMOS et al., 2001). This explains the fact that Pentatomidae predators show higher reproductive rate and population increase with prey and plant (GUEDES et al., 2007).

The number, fertility and viability of eggs and the survival of *P. nigrispinus* were better in the field, even with variations of temperature, relative humidity and rainfall. This demonstrates that the vegetable material improves the development of predatory Pentatomidae even during unfavorable conditions. *Supputius cincticeps* (Stal) and *Brontocoris tabidus* Signoret (Hemiptera: Pentatomidae) also presented better development and reproduction with *T. molitor* pupae on eucalyptus plants than only with this prey (ZANUNCIO et al., 2000). The vegetable material could compensate for the low nutritional quality of prey, because they could supply water and nutrients what would increase the weight, reproduction and longevity of these predators (GUEDES et al., 2007).

The feeding on plants has positive implications for biological control programs with predatory Pentatomidae (LEMOS et al., 2001), because it represents an alternative food source in the laboratory and in the field, especially when the prey is scarce or absent (AZEVEDO et al., 2007). Hence, feeding on vegetable material can improve the permanence of predators in the field and to increase their reproductive rate and survival (RAMALHO et al., 2008).

The release of predators represents a critical stage in biological control programs, because adverse conditions such as low prey availability can reduce the reproductive potential and efficiency of these natural enemies (NAKASHIMA; HIROSE, 1999; WESTICH; HOUGH-GOLDSTEIN, 2001). However, predatory Pentatomidae can use alternative food sources to partially compensate for these conditions (ASSIS JÚNIOR et al., 1999). Hence, the feeding on vegetable material can increase the longevity of these predators in the field (ZANUNCIO et al., 2004). The development and the reproduction of these species can be affected by variations on their food source, because the nutritional value of plants depends on the species and of the natural enemy (WACKERS, 2004).

Conclusion

The presence of *E. urophylla* plants reduced nymph mortality and increased the longevity of adults and the number of eggs and nymphs per female of *P. nigrispinus*. Hence, it is recommended to rear this predator with prey and plant in the laboratory or in the field.

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