DEVELOPMENT AND REPRODUCTION OF *Podisus distinctus* (HETEROPTERA: PENTATOMIDAE) FED ON LARVA OF *Bombyx mori* (LEPIDOPTERA: BOMBYCIDAE)

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(With 1 figure)

ABSTRACT

Biological control has been reducing the use of chemical products against insect pests, specially predatory Pentatomidae. Species of this group can present high variations in their life cycle as a result of their diet. Thus, the objective of this research was to study nymph development and reproduction of *Podisus distinctus* (Stäl, 1860) (Heteroptera: Pentatomidae) fed on *Bombyx mori L.*, 1758 (Lepidoptera: Bombycidae) larvae (T1), compared to those fed on *Tenebrio molitor L.*, 1758 (Coleoptera: Tenebrionidae) (T2) and *Musca domestica L.*, 1758 (Diptera: Muscidae) larvae (T3) at a temperature of 25 ± 0.5ºC, relative humidity of 70 ± 2%, and photophase of 12 h. Predators fed on *B. mori* showed duration of the nymph phase (18.68 ± 1.02) similar to those fed on *T. molitor* (18.32 ± 1.49). Pre-oviposition and oviposition periods and number of egg masses, besides eggs and nymphs per female, were higher with *B. mori* (5.83 ± 2.02; 15.00 ± 7.40; 8.42 ± 1.84; 296.69 ± 154.75; and 228.55 ± 141.04, respectively) while longevity of males and females of *P. distinctus* was 25.76 ± 16.15 and 35.00 ± 16.15 days with *T. molitor*, and 20.57 ± 13.60 and 23.46 ± 12.35 days with *B. mori*, respectively.

Key words: Insecta, predator, alternative prey, *Podisus distinctus.*

RESUMO

Desenvolvimento de *Podisus distinctus* (Heteroptera: Pentatomidae) alimentado com lagartas de *Bombyx mori* (Lepidoptera: Bombycidae)

O controle biológico vem reduzindo o uso de produtos químicos no combate a insetos pragas, com destaque para pentatomídeos predadores, os quais apresentam variações em seu ciclo de vida, principalmente em função do regime alimentar a que são submetidos. Assim, o objetivo deste trabalho foi estudar o desenvolvimento ninfal e a produtividade de *Podisus distinctus* (Stäl, 1860) (Heteroptera: Pentatomidae) alimentado com larvas de *Bombyx mori L.*, 1758 (Lepidoptera: Bombycidae) (T1), comparado com larvas de *Tenebrio molitor L.*, 1758 (Coleoptera: Tenebrionidae) (T2) ou *Musca domestica L.*, 1758 (Diptera: Muscidae) (T3) à temperatura de 25 ± 0,5ºC, umidade relativa de 70 ± 2% e fotoperíodo de 12 h. *P. distinctus*, alimentado com *B. mori*, apresentou semelhante duração da fase ninfal (18,68 ± 1,02) em relação à alimentação com *T. molitor* (18,32 ± 1,49). Os períodos de pré-oviposição e oviposição e os números de ovos postos e de ninfas por fêmea foram maiores com *B. mori* (5,83 ± 2,02; 15,00 ± 7,40; 8,42 ± 1,84; 296,69 ± 154,75; e 228,55 ± 141,04, respectivamente), enquanto a longevidade de fêmeas e machos foi de 25,76 ± 16,15 e 35,00 ± 16,15 dias com *T. molitor* e de 20,57 ± 13,60 e 23,46 ± 12,35 dias com *B. mori*, respectivamente.

Palavras-chave: Insecta, predador, presa alternativa, *Podisus distinctus.*

INTRODUCTION

Biological control can reduce pest populations and maintain environmental balance without utilization or with lower insecticide use, which can improve life quality in different ecosystems (Symondson *et al.*, 2002).

Pentatomidae predators feed on a large variety of insect pests (Schaeffer & Panizzi, 2000) and are cited in Brazil as important natural enemies of eucalyptus- defoliating caterpillars (Zanuncio *et al.*, 1994). Release of these predators against insect pests makes it necessary to study their biology and mass rearing so as to produce the highest possible number of individuals (Zanuncio *et al.*, 2001). For this reason, these natural enemies have been reared with alternative preys such as *Tenebrio molitor L.*, 1758 (Coleoptera: Tenebrionidae), *Musca domestica L.*, 1758 (Diptera: Muscidae), or *Bombyx mori L.*, 1758 (Lepidoptera: Bombycidae) (Beserra *et al.*, 1995; Zanuncio *et al.*, 1996/1997; Molina-Rugama *et al.*, 1997; Nascimento *et al.*, 1997; Jusselino Filho *et al.*, 2001), in addition to artificial diets (Zanuncio *et al.*, 1996; Saavedra *et al.*, 1997; Coracini *et al.*, 1999; De Clercq *et al.*, 1998; and Rojas *et al.*, 2000).

Reproduction of *Podisus distinctus* (Stal, 1860) (Heteroptera: Pentatomidae) has been studied with *T. molitor* and *M. domestica* (Zanuncio *et al.*, 1998); its nymph development, with combinations of *Coelomera lanio* (Dalman) (Coleoptera: Chrysomelidae), *B. mori*, *M. domestica*, or *T. molitor* (Zanuncio *et al.*, 1997); and its nymph weight, with *M. domestica* and *T. molitor* (Oliveira *et al.*, 1999).

It is important to use alternative prey to replace natural ones with high nymph viability, and to produce heavier predator females for successful establishment under field conditions. For this reason, the objective of this research was to evaluate biological aspects of the predator *P. distinctus* fed larvae of *B. mori*, compared to those fed on larvae of *T. molitor* or *M. domestica*.

MATERIAL AND METHODS

This research was developed in the Laboratory of Biological Control of the Centro de Biotecnologia Aplicada à Agropecuária (BIOAGRO) of the Federal University of Viçosa (UFV) in the Municipality of Viçosa, State of Minas Gerais, Brazil. Research was done with a temperature of 25 ± 0.5ºC, relative humidity of 70 ± 2%, and photophase of 12 h.

Egg masses of *P. distinctus* were obtained from a mass-rearing facility of the Laboratory of Biological Control where this predator was fed larva or pupa of *T. molitor*. Egg masses were kept in Petri dishes (9.0 x 1.2 cm) with a cotton wad soaked with distilled water until nymph emergence. Nymphs of *P. distinctus* were individualized in Petri dishes of similar size at the beginning of the second instar until emergence of adults, when they were sexed by the external appearance of their reproductive organs and conditioned in 500 ml plastic pots. Females of *P. distinctus* were mated three days after emergence with males of similar age, and pairs of this predator were maintained in these pots until their death. Nymphs and adults of this predator received one of the alternative preys in treatments T1(larvae of *B. mori*); T2 (pupae of *T. molitor*); and T3 (larvae or pupae of *M. domestica*). These treatments had seven, seven, and five replications, each one represented by two 500 ml pots with a pair of *P. distinctus* for treatments T1, T2, and T3, respectively.

Survival and duration of each instar, numbers of egg masses, of eggs and nymphs per female, periods of pre-oviposition, oviposition, and pos-oviposition, besides longevity and weight of adults of *P. distinctus* 24 h after their emergence, were daily observed. Results were submitted to a variance analysis according to a complete randomized design and means were compared with the test of Duncan at 5% probability level.

RESULTS

Duration of second instar of *P. distinctus* was shorter in T2 (3.46 ± 0.55) and similar in T1 (3.90 ± 0,37) and T3 (3.85 ± 0.55), while third instar was longer in T2 (3.83 ± 0.80) and T1 (3.65 ± 0.66) than in T3 (3.40 ± 0.73). Duration of fourth and fifth instars was longer in T3 and similar in T1 and T2, while duration of the nymph phase of *P. distinctus* was shorter in T2 (18.32 ± 1.49) and T1 (18.68 ± 1.02) than in T3 (19.03 ± 1.40 days) (Table 1).

Survival of *P. distinctus* was 100% in the first instar when this predator did not feed on prey, while it was 91.66 ± 27.87%, 90.00 ± 30.25%, and 85.00 ± 36.00 in treatments T1, T2, and T3 during second instar with similar results between treatments.

Survival during third instar was higher in T1 (96.36 ± 18.89) than in T2 (87.03 ± 33.90) and T3 (80.39 ± 40.09), while this period was similar between treatments in the fourth and fifth instars (Table 2).

Pre-oviposition, oviposition, and post-oviposition of *P. distinctus* females was 5.83 ± 2.02, 15.00 ± 7.40, and 7.82 ± 6.31 days for those fed *B. mori*, while these values were 10.57 ± 3.43, 11.28 ± 9.40, and 3.64 ± 3.42 days and 9.00 ± 3.20, 7.60 ± 1.00, and 5.50 ± 5.80 days for predators which received *T. molitor* or *M. domestica*, respectively (Table 3).

Higher number of egg masses (8.42 ± 1.84), eggs per female (296.69 ± 154.75) (Figure 3), and nymphs per female (228.55 ± 141.04) of *P. distinctus* were obtained with *B. mori* than with *T. molitor* (4.85 ± 1.88, 141.64 ± 98.09, and 80.64 ± 60.70) or *M. domestica* (3.80 ± 1.93, 93.20 ± 24.90, and 34.70 ± 18.70), respectively (Table 3).

Longevity of *P. distinctus* males was 23.46 ± 12.04, 35.00 ± 16.57, and 19.20 ± 8.35 days with *B. mori*, *T. molitor*, and *M. domestica*, respectively with higher values in T2, while longevity of females of this predator was 20.57 ± 14.86 days in T1 and 20.30 ± 9.33 days in T3, with higher values in T2 (25.76 ± 13.60 days) (Fig. 1).

With all prey, famales of *P. distinctus* were heavier than males with weight of 99.59 ± 12.35, 86.54 ± 8.90, and 73.80 ± 7.10 mg, and 76.37 ± 16.08, 70.00 ± 8.20 and 64.80 ± 10.96 mg for males in T1, T2, and T3, respectively (Fig. 1).

TABLE 1
Duration (days) (mean ± standard error) of II, III, IV, and V instars and of the nymph phase of *Podisus distinctus* (Heteroptera: Pentatomidae) fed on *Bombyx mori* (Lepidoptera: Bombycidae) (T1), *Tenebrio molitor* (Coleoptera: Tenebrionidae) (T2) or *Musca domestica* (Diptera: Muscidae) (T3) at temperature of 25 ± 0.5ºC, relative humidity of 70 ± 2%, and fotophase of 12 hours.

	Treatments		
Instars	**T1**	**T2**	**T3**
II	3.90 ± 0,37 a	3.46 ± 0.55 b	3.85 ± 0.55 a
III	3.65 ± 0.66 ab	3.83 ± 0.80 a	3.40 ± 0.73 b
IV	4.12 ± 0.68 b	4.17 ± 0.70 b	4.63 ± 0.68 a
V	6.00 ± 0.55 ab	5.85 ± 0.47 b	6.14 ± 0.73 a
Total (instars II-V)	18.68 ± 1.02 ab	18.32 ± 1.49 b	19.03 ± 1.40 a

Means followed by the same letter in a row do not differ from each other at 5% probability level by Duncan's multiple range test.

TABLE 2
Survival (%) (mean ± standard error) during II, III, IV, and V instars and of the nymph phase of *Podisus distinctus* (Heteroptera: Pentatomidae) fed *Bombyx mori* (Lepidoptera: Bombycidae) (T1), *Tenebrio molitor* (Coleoptera: Tenebrionidae) (T2), or *Musca domestica* (Diptera: Muscidae) (T3) at temperature of 25 ± 0.5ºC, relative humidity of 70 ± 2%, and fotophase of 12 hours.

	Treatments		
Instars	**T1**	**T2**	**T3**
II	91.66 ± 27.87 a	90.00 ± 30.25 a	85.00 ± 36.00 a
III	96.36 ± 18.89 a	87.03 ± 33.90 ab	80.39 ± 40.09 c
IV	98.11 ± 13.73 a	91.48 ± 28.20 a	95.12 ± 21.80 a
V	96.15 ± 19.41 a	100.00 ± 0.00 a	92.30 ± 26.99 a
Total (instars II-V)	83.33 ± 27.87 a	71.67 ± 45.44 ab	60.00 ± 09.40 b

Means followed by the same letter in a row do not differ from each other at 5% probability level by Duncan's multiple range test.

TABLE 3
Mean ± standard error of biological parameters of *Podisus distinctus* (Heteroptera: Pentatomidae) females fed *Bombyx mori* (Lepidoptera: Bombycidae) (T1), *Tenebrio molitor* (Coleoptera: Tenebrionidae) (T2), or *Musca domestica* (Diptera: Muscidae) (T3) at temperature of 25 ± 0.5ºC, relative humidity of 70 ± 2% and fotophase of 12 hours.

Parameters evaluated	T1	T2	T3
Pre-oviposition (days)	5.83 ± 2.02 c	10.57 ± 3.43 a	9.00 ± 3.20 b
Oviposition (days)	15.00 ± 7.40 a	11.28 ± 9.40 b	7.60 ± 1.00 c
Post-oviposition (days)	7.82 ± 6.31 a	3.64 ± 3.42 c	5.50 ± 5.80 b
Egg masses (number)	8.42 ± 1.84 a	4.85 ± 1.88 b	3.80 ± 1.93 c
Number of eggs	296.69 ± 154.75 a	141.64 ± 98.09 b	93.20 ± 24.90 c
Nymphs/treatment (number)	228.55 ± 141.04 a	80.64 ± 60.70 b	34.70 ± 18.70 c

Means followed by the same letter in a row do not differ from each other at 5% probability level by Duncan's multiple range test.

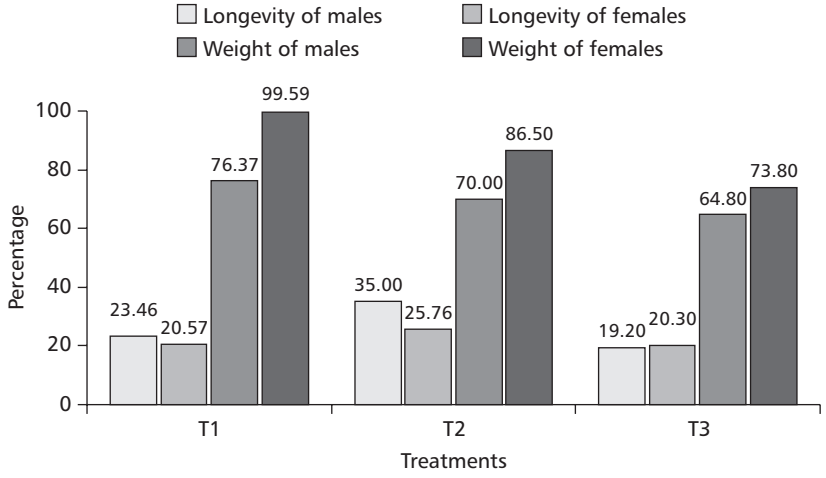

Fig. 1 — Weight and longevity of *Podisus distinctus* (Heteroptera: Pentatomidae) fed *Bombyx mori* (Lepidoptera: Bombycidae) (T1), *Tenebrio molitor* (Coleoptera: Tenebrionidae) (T2), or *Musca domestica* (Diptera: Muscidae) (T3) at temperature of 25 ± 2ºC, relative humidity of 70 ± 5% and photophase of 12 hours.

DISCUSSION

Duration of the nymph phase of *P. distinctus* was longer with *B. mori* than with *T. molitor* and *M. domestica*, and that of fourth instar was also longer with this prey, which can be related to its poor quality. This shows that *P. distinctus* needs a longer nymph period to develop its reproductive organs to develop when fed poor-quality prey such as *M. domestica* (Zanuncio *et al.*, 1998). Moreover, predatory Asopinae (Heteroptera) fed with better-quality food are heavier with higher reproduction, fecundity, and number of eggs and nymphs (Evans, 1982; Zanuncio *et al.*, 1996). Other species of this group showed similar necessities because the nymph period of *P. distinctus* was also shorter when this predator was fed *B. mori*. This agrees with results for the predators *Podisus sculptus* (Distant) (Heteroptera: Pentatomidae) (Nascimento *et al.*, 1997) and *P. nigrispinus*, with longer duration of the nymph phase with *M. domestica* (Zanuncio *et al.*, 1996/1997).

P. distinctus showed higher nymph survival in T1 (83.33 ± 27.87%) than in T2 (71.67 ± 45.44%)

and T3 (60.00 ± 49.60%). This survival was higher with *T. molitor* and lower with *M. domestica* than that reported by Zanuncio *et al*. (1998) for this predator. This can be due to an adaptation process of *P. distinctus* after several generations in the laboratory.

The pre-oviposition period of *P. distinctus* was shorter in treatment T1 which shows that *B. mori* is a better quality prey; it also indicates that females of predators can more rapidly obtain nutrients for egg production with this prey than with *T. molitor* (Jusselino Filho *et al.*, 2001). Moreover, oviposition and post-oviposition periods were longer when this predator was fed *B. mori*, further evidencing the quality of this prey, as does higher reproductive capacity of *P. distinctus*, in a manner similar to that reported for *Podisus maculiventris* (Say, 1831) (Heteroptera: Pentatomidae) (O'Neil & Wiedenmann, 1990).

P. distinctus showed a higher number of egg masses, eggs, and nymphs per female with *B. mori*, while results for *M. domestica* and *T. molitor* were similar to those of Zanuncio *et al.* (1998). This shows again the better quality of *B. mori* for different species of predatory Pentatomidae because *Podisus nigrolimbatus* (= *Brontocoris tabidus* Signoret, 1852) (Zanuncio *et al.*, 1993), *Podisus sculptus* Distant, 1889 (Heteroptera: Pentatomidae) (Nascimento *et al.*, 1997), and *Podisus connexivus* Bergrot, 1891 (= *Podisus nigrispinus* Dallas, 1851) (Heteroptera: Pentatomidae) (Zanuncio *et al.*, 1996/1997), also performed better with *B. mori* than with *T. molitor* or *M. domestica*.

Longevity of *P. distinctus* females was similar with *B. mori*, *T. molitor*, and *M. domestica*, suggesting that this generalist predator can maintain its longevity with different prey, and agreeing with reports of Zanuncio *et al.* (1997), but with reduced egg and nymph production which can limit the establishment. of *P. distinctus* in the field.

B. mori should be used when a higher number of individuals specially in mass-rearing programs of *P. distinctus* is necessary because this predator showed a higher number of eggs and nymphs and better nymph viability with this prey. However, the high costs of rearing *B. mori*, including the necessity of maintaining a mulberry crop and more specialized work, as well as coping with deficiency of leaves of this plant between crops, restricts the use of this prey to only when necessary in order to maintain a colony of this predator in the laboratory (Zanuncio *et al.*, 1996/1997; Zanuncio *et al.*, 1998; Oliveira *et al.*, 1999). Although it is possible to maintain *P. distinctus* with *M. domestica* larva, the use of this prey is not recommended due to consequent low egg and nymph production, as well as survival of this predator. For these reasons the colonies of *P. distinctus* should be reared with *T. molitor* pupae in laboratory.

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