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Predation Rate of *Spodoptera frugiperda* (Lepidoptera: Noctuidae) Larvae With and Without Defense by *Podisus nigrispinus* (Heteroptera: Pentatomidae)

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ABSTRACT

The effect of the defense of the prey Spodoptera frugiperda *(J.E. Smith) (Lepidoptera: Noctuidae) on predation rates of* Podisus nigrispinus *(Dallas) (Heteroptera: Pentatomidae) females was studied.* P. nigrispinus *preyed 1.0, 1.4, 1.2, 3.8 and 3.0 and 0.4, 0.8, 1.6, 2.8 and 3.2 third instars of* S. frugiperda *larvae with and without defense, respectively, with the densities of one, two, four, six and eight larvae. The attack rate and the manipulation time were, respectively, 0.67 ± 0.39^{-h} and 6.72 ± 2.88 h for* P. nigrispinus *females fed with larvae with defense and 2.51 ± 0.16^{-h} and 0.51 ± 0.77 h for those without defense. The functional response of the predator* P. nigrispinus *varies with the defense and the density of the prey* S. frugiperda, *with larger consumption of prey without defense at higher densities.*

Key words: Asopinae, biological control, predator, functional response

INTRODUCTION

Spodoptera frugiperda (J.E. Smith) (Lepidoptera: Noctuidae) is a polyphagous caterpillar damaging plants of economic importance such as, corn, wheat, rice, bean, peanut, tomato, potato, cabbage, spinach, pumpkin, collard greens and cotton (Cruz et al., 1999). The control of this pest presents problems, mainly, with the introduction of corn plantation in the winter in regions where irrigation infrastructure is adequate. *Spodoptera frugiperda* can attack corn plants at any time of the year and, for this reason, the frequency and intensity of the use of insecticides such as pirethroids and organophosphates has led to failures on the control of this pest (Diaz-Rodriguez and Omoto, 2001).

The biological control represents an important strategy to reestablish the biodiversity of agricultural agroecossystems, especially with the introduction of entomophagous organisms with classic innoculative techniques or the increase of natural populations of predators, parasitoids and pathogens (Silva, 2000).

The generalist predator *Podisus nigrispinus* (Dallas) (Heteroptera; Pentatomidae) is widespread in the Neotropical region (Thomas, 1992) where it has been reported feeding on Lepidoptera pests such as *S. frugiperda* larvae (Batalha et al., 1997; Zanuncio et al., 1998). This

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showed that this predator could be used in programs of biological control of *S. frugiperda*, making important to determine its control potential against this pest.

Predators play an important role in the maintenance of the aggressiveness and the energy of the preys by eliminating those with lower defense capacity while the ones with better aptitude can survive and reproduce (Price, 1975). For this reason, these natural enemies act as agents for the evolution of the prey by selecting stronger and vigorous individuals. On the other hand, the predators develop more efficient techniques to attack their preys (Azevedo and Ramalho, 1999a, b; Lemos et al., 2005). Factors such as the densities of the prey and predators, environmental conditions, mechanisms of prey defense and strategies of attack of the predator can interfere in the predation process (Holling, 1959). Therefore, the knowledge of the effects of prey defense on the functional response of predators is important to understand the mechanisms involved in the system of co-evolution predator-prey.

The objective of this study was to determine the predation rate of *P. nigrispinus* in *S. frugiperda* larvae with and without defense.

MATERIAL AND METHODS

The experiment was developed in the laboratory of Biological Control of Insects of the Federal University of Viçosa (UFV) in the Municipality of Viçosa, State of Minas Gerais, Brazil at 25 ± 1°C, 68 ± 10% relative humidity and 12 hours photo phase. Specimens of the predator *P. nigrispinus* and of the prey *S. frugiperda* were obtained from the Institute of Applied Biotechnology to Agriculture (BIOAGRO) reared according to Zanuncio et al. (1994) and fed diet of Shorey and Hale (1965), respectively. A total of 300 eggs of *S. frugiperda* were selected and put in Petri dishes with paper filter until hatching of the caterpillars, which were fed with corn leaves up to the third instar. Five days old newly mated *P. nigrispinus* females were individualized in an experimental arena and starved for 24 h. The experimental arena consisted of a plastic cylinder (8 cm high, 14 cm in diameter), the top of which was covered by a plastic Petri dish. After this period, a total of one, two, four, six or eight third instars *S. frugiperda* larvae, with or without defense, were transferred per arena with five replications. The larvae without defense were, partially, immobilized with 0.15mm entomological pins, inserted in the ventral part of their mesothorax (Silva et al., 1996). All the insects were weighed before starting the study.

The statistical analysis was accomplished with the R Statistical System (Ihaka and Gentleman, 1996) (http://termix.ufv.br/CRAN). The regression analyses were used to determine the type of functional response and to compare the predation rate of *P. nigrispinus* females with several densities and with or without defense of *S. frugiperda* larvae. The sign of the linear coefficient estimated with the regression logistics (negative or positive) can be used to distinguish the shape of the curve of the functional response (types II or III, respectively) (Trexler et al., 1988; De Clercq et al., 2000). The attack rate (a) and the manipulation time (Th), used to establish the equation of the functional response, were determined after its linearization according to Woolf (Nt/Na= Th Nt+a-1) (Currie 1982, Fan and Petitt, 1994). Therefore, the manipulation period of prey (Th) can be determined with simple linear equation by plotting the data of Nt/Na versus Nt (ÿ= a + bx) and multiplying the total exposition time (T) by the angular coefficient of this straight line (b). The attack rate (a) corresponds to the intercept of the straight line (1/a) (Fan and Petitt, 1994).

RESULTS

The survival of *S. frugiperda* larvae was higher than the 98% in the absence of the predator what did not make necessary to correct these data. The average weight of larvae of this prey and of females of the predator *P. nigrispisnus* was 113.47 ± 44.68 mg and 65.40 ± 12.14 mg, respectively. Each *P. nigrispinus* female preyed 1.0, 1.4, 1.2, 3.0 and 3.8 *S. frugiperda* larvae with defense and 0.4, 0.8, 1.6, 2.8 and 3.2 larvae without defense with the densities of one, two, four, six and eight larvae per arena. The high predation rates were observed in the densities of six and eight larvae per arena, with and without defense, respectively. The density and the interaction density versus prey defense were significant, but the effect of the prey defense was not observed separately (Table 1). The number of *S. frugiperda* larvae preyed by *P. nigrispinus* female showed an increase tendency at all densities (Fig. 1). The regression curves fitted

for *S. frugiperda* larvae with and without defense showed different functional responses (Fig. 1).

The attack rate (a) and the manipulation time (Th) of *S. frugiperda* larvae with defense (Table 2) were 0.67 ± 0.39^{-h} and 6.72 ± 2.88 h. These values were lower than the attack rate (a) of 2.51 ± 0.16^{-h} and larger than the manipulation time (Th) of 0.51 ± 0.77 hours for larvae without defense.

DISCUSSION

Podisus nigrispinus presented a functional response of type II (Holling, 1961) with *S. frugiperda* (Hübner) larvae with defense. This was similar to that reported for the females of this predator with larvae of *Spodoptera exigua* Hübner and *Chrysodeixis chalcites* (Esper) (Lepidoptera: Noctuidae) (De Clercq et al., 1998; Mohaghegh et al., 2001). *Podisus nigrispinus* presented a type I functional response (Holling, 1961) with *S. frugiperda* larvae without defense. This response was considered a theoretical model because the number of individuals preyed increased linearly with their density (Van den Bosch et al., 1982). This indicated that the model of the functional response presented by *P. nigrispinus* could be influenced by the lowest defense capacity of *S. frugiperda* larvae immobilized with pins. Substandard individuals were captured disproportionately when the type of prey was difficult to capture but not when it was easy to capture (Krebs, 2001).

The functional response of *P. nigrispinus* was affected by the defense of *S. frugiperda* larvae at the same density. This could be explained by the different values of intercepts of the regression curves and it demonstrated that the defense of the prey when at low densities had low impact on predation rates by *P. nigrispinus.* Defenses of phytophagous insects include behavioral pattern, chemistry, morphologic and physiologic traits that are effective against natural enemies (Witz, 1990, Gross, 1991, Dyer, 1995). *Podisus nigrispinus* can select prey with minor potential defense in conditions of abundance of them which can reduce unnecessary expenses of energy. *Podisus maculiventris* (Say) (Heteroptera: Pentatomidae) selected fifth instar larvae according to their capacity of defense with different manipulation time and preyed larger number of larvae without defense (Morris, 1963). This was demonstrated also for the predator *Supputius cincticeps* (Stäl) (Heteroptera: Pentatomidae) with growth rates, rates of daily and total relative consumption, efficiency of food conversion and weight depending on the defense of the preys and also on the temperature (Azevedo and Ramalho, 1999a,b). This showed that the knowledge of the defense mechanisms of the prey is important and it can be used, isolated or combined, with attributes of this predator such as reproductive capacity and searching rate and density-dependence to define release techniques.

Table. 1 - Variance analysis of the effect of the density (D) and defense (DP) of *Spodoptera frugiperda* (Lepidoptera: Noctuidae) larvae on preying rates of *Podisus nigrispinus* (Heteroptera: Pentatomidae) females

Variation source	DF	Deviance	F	P
Density (D)	1	3.08	44.849	0.000^{***}
Prey defense (DP)	1	0.05	0.820	0.400
D x DP	1	0.47	6.855	0.039^{*}
Residue	6	0.48	-	-

$^{(*)}$Significant ($P< 0.05$)
$^{(***)}$Significant ($P< 0.001$)

Table. 2 - Effect of the defense of the prey on the attack rate (a) and manipulation time (Th) of *Podisus nigrispinus* (Heteroptera: Pentatomidae) females on third instars of *Spodoptera frugiperda* (Lepidoptera: Noctuidae) larvae

Parameter	With defense	Without defense
a (h^{-1})	0.67 ± 0.39	2.51 ± 0.16
T_h (h)	6.72 ± 2.88	0.51 ± 0.77

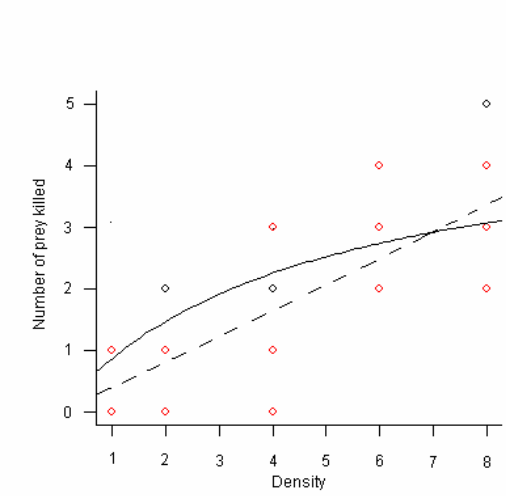

Figure 1 - Functional response of *Podisus nigrispinus* (Heteroptera: Pentatomidae) as function of the density of *Spodoptera frugiperda* (Lepidoptera: Noctuidae) with (O, solid line) or without defense (O, broken line).

The high attack rates (a) and the lower manipulation time (Th) of *P. nigrispinus* on *S. frugiperda* larvae without defense, suggested that defense movements of the prey favor its finding by predators, but they could hinder their manipulation by these natural enemies. The attack rate (a) and the manipulation time (Th) of third instars of *S. frugiperda* larvae with defense by *P. nigrispinus* had higher values than those for this predator preying third instar *S. exigua* larvae (Mohaghegh et al., 2001). For this reason, the attack rate and the manipulation time of this predator could depend on the defense and prey used.

To conclude, functional response of the predator *P. nigrispinus* varied with the defense and the density of the prey *S. frugiperda*, with larger consumption of preys without defense when they were at high densities.

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RESUMO

Objetivou-se determinar o efeito da defesa da presa *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae) na taxa de predação por fêmeas de *Podisus nigrispinus* (Dallas) (Heteroptera: Pentatomidae). *Podisus nigrispinus*, predou 1,0; 1,4; 1,2; 3,8; 3,0 lagartas de terceiro estádio de *S. frugiperda* com defesa, respectivamente, nas densidades de uma, duas, quatro, seis e oito lagartas, enquanto esses valores foram de 0,4; 0,8; 1,6; 2,8; 3,2 lagartas sem defesa, respectivamente, nessas densidades. A taxa de ataque (*a*) e o tempo de manipulação (T_h) foram, respectivamente, de 0,67 ± $0,39^{-h}$ e 6,72 ± 2,88 horas para fêmeas de *P. nigrispinus* alimentadas com lagartas com defesa e de 2,51 ± $0,16^{-h}$ e 0,51 ± 0,77 horas para aquelas sem defesa. A resposta funcional do predador *P. nigrispinus* varia com a defesa e a densidade da presa *S. frugiperda*, com maior consumo de presas sem defesa em altas densidades.

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