

Functional Response of the Predator *Eriopis connexa* (Coleoptera: Coccinellidae) to Different Prey Types

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ABSTRACT

This work evaluated the functional response of adult females of *Eriopis connexa* to different densities of *Macrosiphum euphorbiae* and *Tetranychus evansi*. When preying upon aphids, *E. connexa* presented a sigmoidal functional response (Type III). This behavior, however, changed drastically to an exponential (Type II) functional response, when mites (*T. evansi*), rather than aphids, were offered to *E. connexa*. Such different patterns showed that this coccinellid needed to adopt distinct strategies according to the kind of prey available. Since predators were believed to be able to regulate prey populations only when adopting Type III functional response, *E. connexa* would be a good candidate for a biological control agent of *M. euphorbiae*, but would not suppress a growing population of *T. evansi*.

Key words: Biological control, coccinellids, aphids, mites, *Lycopersicon esculentum* Mill

INTRODUCTION

Insect predators are frequently reckoned as effective regulators of insect pest populations (DeBach and Rosen, 1991; Price, 1997; Obrycki, 1998; Cardoso and Lazzari, 2003; Padmalatha et al., 2003), which has led their increasing use in insect pest management programs (Wiedenmann and Smith, 1997; Riudavets and Castane, 1998). This occurs mainly due to the current need to reduce the exclusive use of insecticides for pest control, as well as to avoid increments in doses or utilization of highly toxic chemicals (Gravena, 1989). As a consequence, biological control stands as a profitable alternative to the use of chemicals in the agroecosystem (Lester et al., 2000).

Coccinellids have been receiving attention as biological control agents, due to their ability to feed on a large number of preys (Obrycki, 1998; Iskber and Copland, 2002; Oliveira et al., 2004). For most species, both adult and larvae are considered potential predators of a wide range of prey, including aphids (Hagen, 1962; Oliveira et al., 2004) and phytophagous mites, which cause serious damage to tomato plants all over the world (Flechtmann, 1983; Obrycki, 1998; Moreira et al., 2004).

Eriopis connexa (Coleoptera: Coccinellidae), for instance, is a coccinellid very effective in keeping alfalfa's aphids below the economic threshold level, especially in spring (Hodek 1973). In Brazil, *E. connexa* is frequently found in tomato crops (Sarmiento et al., 2004), where it is considered a

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potential biological control agent. Scientific studies aiming to check such a supposition are, however, scarce. Among such studies, functional response curves are needed, in order to evaluate the extent to which predatory activity is modified by prey density. Functional response curves refer to the change in the number of prey eaten per predator per time unit, as a function of prey density (Gitonga et al., 2002). Such curves uncover prey-predator interactions, allowing forecasting the suitability of a predator as a biological control agent (Wiedenmann and Smith, 1997). This work aimed to investigate the suitability of *E. connexa* as a biological control agent for the aphid *Macrosiphum euphorbiae* (Hemiptera: Aphididae) and the mite *Tetranychus evansi* (Acari: Tetranychidae), which are important solanaceous crops pests in Brazil (Flechtmann 1983, Maluf et al. 2001, Boll and Lapchin 2002, Sarmiento et al. 2004).

MATERIALS AND METHODS

Predators' rearing

Wild adults of *E. connexa* were collected from tomato plants. Five males and five females were confined together in plastic containers (2.0 cm diameter x 10 cm high) at $25 \pm 1^\circ\text{C}$ and $70 \pm 10\%$ relative humidity, fed on *M. euphorbiae* and *T. evansi*, in order to provide eggs from which adults were obtained for the functional response experiments. Eggs laid were collected from the walls of the container and transferred to Petri dishes (5.0 cm diameter x 1.5 cm high), where they were kept until their eclosion. Larvae were then individualized in Petri dishes, and fed on *M. euphorbiae* and *T. evansi* until reach the adult age. Hence, adults of same sex and age were selected to run the experiments.

Aphids' rearing

Wild adults and nymphs of *M. euphorbiae* were collected from tomato plants at the same place of *E. connexa*. Such aphids were then transferred to tomato plants from 'Santa Clara I-5300' variety, and kept in greenhouse. Tomato plants were 23 days old, bore eight leaves, and were replaced every two weeks.

Mites' rearing

Adults and nymphs of *T. evansi* were collected from tomato plants kept in greenhouses. They were then transferred to tomato plants from 'Santa Clara I-5300' variety, kept in another greenhouse compartment. Tomato plants were 23 days old, bore eight leaves, and were replaced every three weeks.

Functional response experiments

Recently mated 24h-old adult females of *E. connexa* were confined alone in plastic containers (2.0 cm diameter x 10 cm high), along with their prey (aphids or mites) kept at a known density. No container held both the preys. Preliminary tests helped to establish prey densities, which were 50, 100, 150, 200 and 300 individuals per container for the mite, and 5, 10, 20, 30 and 40 for the aphid. Each density was repeated five times. Predatory activity of *E. connexa* was recorded periodically from 24 to 72h since the beginning of the experiment. At each observation missing, or killing prey was replaced, in order to keep original density. Experiments were run at $25 \pm 1^\circ\text{C}$, $70 \pm 10\%$ relative humidity, and photoperiod 12: 12h.

Statistical Analyses

The functional response of *E. connexa* to each prey (*M. euphorbiae* and *T. evansi*) was tested separately, aiming to identify whether this response was of Type II, or Type III. To do so, two- and three-parameter models were fitted to data through non-linear regression. After parameter estimation, each model was checked against a null model (containing the intercept only), in order to verify its global significance. If both, Type II and Type III models, presented minimal significance ($P < 0.05$), they were tested against each other, to check whether the simplest model would convey the same information as the more complex one. In such case, parsimony would oblige to opt to the simplest model.

Type II models obeyed the equation

$$y = a \cdot e^{\frac{b}{x}}$$

Type III models obeyed the equation

$$y = \frac{a}{1 + b \cdot e^{-c \cdot x}}$$

In these equations, y is the number of consumed prey, x is the number of offered prey, and a , b , and c are controlling parameters for the curve. Since our aim is to identify solely whether a response follows Type II or Type III equations, we do not analyze the biological meaning of its controlling parameters.

All statistical analyses were performed using R Statistical Package (Ihaka and Gentleman, 1996; R Development Core Team, 2004). Non-linear regressions used package `nls` and comparisons between models used command `anova`.

RESULTS

Functional response of *E. connexa* changed according to the prey offered. Both, Type II and Type III models explained the functional response of *E. connexa* beetles to *M. euphorbiae* aphids better than the null model. Type II model, however, showed significantly less information than Type III model, which meant that when preying upon aphids (*M. euphorbiae*), *E. connexa*

presented a functional response of Type III (Table 1), obeying the equation:

$$y = \frac{31.5}{1 + 14.43 \cdot e^{\frac{-69.89}{x}}}$$

where y is the number of *M. euphorbiae* individuals preyed by *E. connexa*, and x is the number of prey individuals offered (Fig. 1).

Accordingly, both models explained the functional response of *E. connexa* beetles to *T. evansi* better than the null model. But in this case, Type II model conveyed the same information as Type III model. Parsimony, therefore, obliged to choose the simplest model (Type II) as the actual descriptor of the functional response of *E. connexa* upon *T. evansi* (Table 2), obeying the equation:

$$y = 195.7 \cdot e^{\frac{-69.89}{x}}$$

where y is the number of *T. evansi* individuals preyed by *E. connexa*, and x is the number of prey individuals offered (Fig. 2).

Table 1 - Comparisons between statistical models used to explain the functional response of *E. connexa* beetles preying upon *M. euphorbiae* aphids. 'df (diff)' are the difference in degrees of freedom between the two models being compared and 'df (res)' are the residual degrees of freedom for such a comparison; 'null' is the model containing the intercept only. See Results for the equations for Type II and Type III models.

Models compared	df (diff)	df (res)	F	P
Type II x null	1	24	354.34	1.8E-15
Type III x null	2	24	315.74	<2.2E-16
Type II x type III	1	23	17.83	3.5E-04

Table 2 - Comparisons between statistical models used to explain the functional response of *E. connexa* beetles preying upon *T. evansi* mite. 'df (diff)' are the difference in degrees of freedom between the two models being compared and 'df (res)' are the residual degrees of freedom for such a comparison; 'null' is the model containing the intercept only. See Results for the equations for Type II and Type III models.

Models compared	df (diff)	df (res)	F	P
Type II x null	1	24	163.70	6.08E-12
Type III x null	2	24	95.31	1.46E-11
Type II x type III	1	23	4.19	0.053

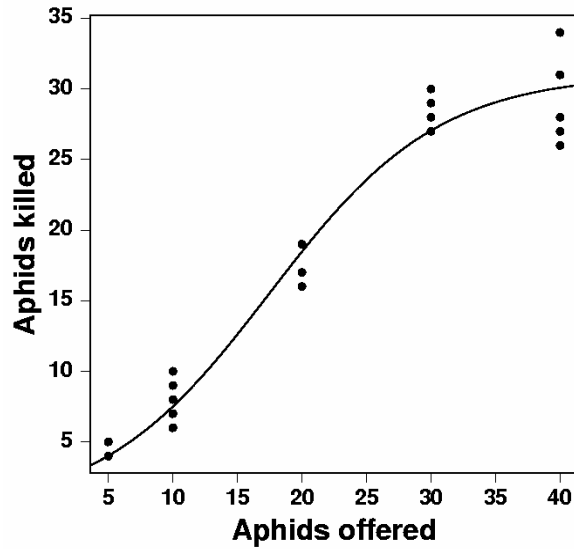


Figure 1 - Functional response of *Eriopis connexa* preying upon different densities of *Macrosiphum euphorbiae*.

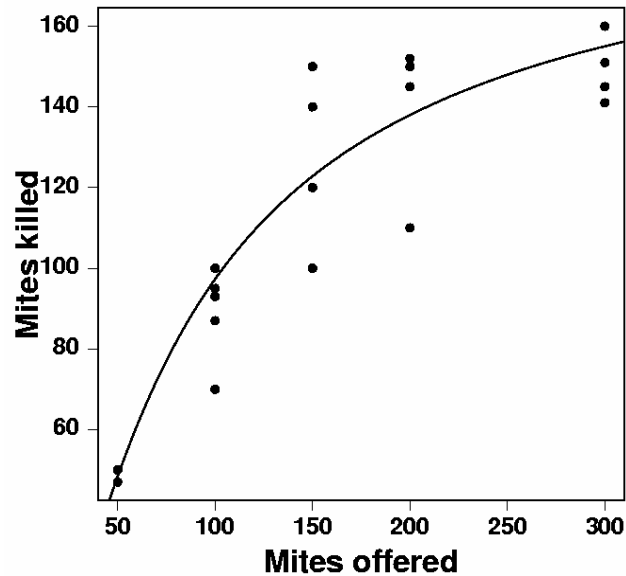


Figure 2 - Functional response of *Eriopis connexa* preying upon different densities of *Tetranychus evansi*.

DISCUSSION

The coccinellid *E. connexa* presented functional responses that varied according to the prey considered. When preying upon *M. euphorbiae* aphids, this predator presented a sigmoidal curve

(Type III, Table 1, Fig. 1), whereas this behavior changed to an exponential curve (Type II), when the coccinellid preyed upon *T. evansi* (Table 2, Fig. 2). Sigmoidal curves for functional responses have already been reported for coccinellids preying upon aphids for *Coccinella septempunctata*

feeding on *Brevicoryne brassicae* (Munyaneza and Obrycki, 1997). Such a behavior denoted situations when predators increased their rate of attack as prey density increases (Hassell, 1978), which could indicate that the predator learned how to circumvent some difficulty associated to catching the prey (Schenk and Bacher, 2002). Such difficulties at low prey densities could vary from a simple impairment to locate next prey, to an active scape of prey as a response to alarm pheromones. Specifically for aphids, alarm pheromones could play an important role on predator avoidance (Montgomery and Nault, 1977). It seemed, therefore, that the efficiency of *E. connexa* as a predator of *M. euphorbiae* was improved when these aphids presented large populations.

The response of *E. connexa* to *T. evansi* was rather different from its response to aphids. Predation by the coccinellid upon the mite obeyed an exponential function, which represented a situation when the rate of attack by the predator decreases monotonically from low to high densities. In this type of functional response, there was no initial delay in predation, evidencing the absence of an initial period during which the predator learnt ways to circumvent difficulties. Predators foraging in accordance to an exponential curve, therefore, did not improve efficiency as prey density increased. This would mean either (i) that *T. evansi* had effective defense strategies, which were not surpassed by the coccinellid, or (ii) that *T. evansi* presented no defense strategies at all, in such a way that the coccinellid was preying *ad libitum*, not needing to improve prey intake whatsoever. Evidences seemed to point to the first option: the mite might have presented effective defense strategies. Effective defense strategies are already known for *Tetranychus urticae* (Koch) (Acari: Tetranychidae), whose webs impair predatory activity of *Orius laevigatus* (Fieber) (Hemiptera: Anthocoridae) on *Frankliniella occidentalis* (Pergande) (Thysanoptera: Thripidae) (Venzon et al., 2000). Similarly, *T. evansi* also spin webs, which may have impaired the activity of the predator under test.

Thus, although *E. connexa* might prey upon *M. euphorbiae* as well as on *T. evansi*, it was more effective when preying on the aphid, rather than on the mite. The actual mechanism responsible for such a difference needs further enlightenment. It could be said, however, that this coccinellid presented better potential for biological control

programs focused on the aphids rather than on the mites.

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RESUMO

Estudos de resposta funcional fornecem informações importantes, que podem ajudar na escolha de agentes de controle biológico. Este trabalho avaliou a resposta funcional de fêmeas adultas de *Eriopis connexa* para diferentes densidades de *Macrosiphum euphorbiae* e *Tetranychus evansi*. *Eriopis connexa* apresentou uma resposta funcional sigmoidal (Tipo III) quando teve afídeos como presa. Este comportamento mudou drasticamente para uma resposta funcional exponencial (Tipo II), quando ácaros (*T. evansi*) foram oferecidos para *E. connexa* ao invés de afídeos. Essa mudança de comportamento, evidencia que esse coccinélido precisa adotar estratégias diferentes de acordo com o tipo de presa disponível. Acreditar-se que predadores podem regular populações de presa somente ao adotar uma resposta funcional Tipo III. Nós concluímos que *E. connexa* seria um bom candidato para agente de controle biológico de *M. euphorbiae*, mas não suprimiria uma população crescente de *T. evansi*.

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