

**Effect of host plant morphological features on functional response of *Orius albidipennis* (Hemiptera : Anthocoridae) to *Tetranychus urticae* (Acari : Tetranychidae)**

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**ABSTRACT**

Effect of host plant on the functional response of *Orius albidipennis* females to densities of egg or adult female of *Tetranychus urticae* was investigated using cucumber and strawberry plants that differ in leaf morphological features. The functional response experiments of predatory bugs on egg and adult female of *T. urticae* were examined over 24 and 8 h periods, respectively. Logistic regression analysis revealed that *O. albidipennis* predation fitted reasonably well to both type II and III functional response models. Predators showed type II response to adult female of *T. urticae* on both host plants but they had type III response to *T. urticae* eggs on their host plants. Attack rates (a) of predatory bug to adult female of *T. urticae* on cucumber and strawberry were 0.031 and 0.047/h, respectively. Moreover, attack coefficient b, which describes the changes in attack rate with prey densities in a type III response ( $a=bN$ ), of *O. albidipennis* to *T. urticae* eggs on cucumber and strawberry was 0.001 and 0.004/h, respectively. Predator handling times ( $T_h$ ) to adult female and *T. urticae* eggs on cucumber were greater than those on strawberry, with estimated values of 0.94 vs. 1.54 and 0.81 vs. 0.76 h for adult female vs. *T. urticae* eggs on cucumber and strawberry, respectively. The implications of these results for the tritrophic interactions between plant, prey and predator, and the development of suitable biological control strategies are discussed.

**Key words :** Biological control, functional response, host plant, *Orius albidipennis*, *Tetranychus urticae*, Tritrophic interaction

**INTRODUCTION**

One of the important elements describing predator-prey relationships is the predator's functional response, which relates the change in prey consumption to increasing prey density (Holling, 1959; Murdoch and Oaten, 1975). Functional response is conveniently classified into three general types named I, II and III, which describe, respectively, linear, non-linear with saturation and sigmoid patterns (Holling, 1959; Hassell, 1978). This phenomenon is not only mediated by predator-prey interactions, but is also affected by host plant characteristics (Coll and Ridgway, 1995). In general, both morphological features (e. g.

leaf hairs and trichomes) and biochemical aspects (e. g. volatile substances and toxic compounds) of host plants directly and/or indirectly influence natural enemy's success in searching for and controlling the herbivores (Price *et al.*, 1980; Bottrell *et al.*, 1998; Messina and Hanks, 1998; Moayeri *et al.*, 2006 a,b). Several studies have shown simple changes in plant morphology and can hinder the searching ability of natural enemies by mechanically hindering the movement of predators and parasites (Sütterlin and Van Lenteren 1997; Croft *et al.*, 1999; Stavrinides and Skirvin 2003). As searching ability is a major factor in determining the functional response of natural enemies, altered searching efficiency caused by

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variations in plant morphology, could also affect predator functional response (De Clercq *et al.*, 2000; Koveos and Broufas, 2000; Cedola *et al.*, 2001; Skirvin and Fenlon, 2001; Madadi *et al.*, 2007).

Strawberry and cucumber plant species are important crops in the center and north of Iran and differ, among other things, for feature of their leaves. Strawberry leaves are covered with infrequent fragile trichomes (Ferrer *et al.*, 1993; Mahr *et al.*, 2001; Steinite and Levinsh, 2003), while the leaves of cucumber are floored with straight dense trichomes (Ferguson and Schmidt, 1996; Mahr *et al.*, 2001; Madadi *et al.*, 2007). These crops are constantly infested by two-spotted spider mite, *Tetranychus urticae* Koch (Acari: Tetranychidae) (TSSM) (Tehraniifar and Sarsaefi, 2002; Arbabi, 2007), but those are prone for biological control of TSSM because of naturally occurring predatory species such as the minute pirate bug, *Orius albidipennis* (Hemiptera: Anthocoridae), (Ostovan and Mirhelli, 2005).

*O. albidipennis* is an effective predator and several studies have been carried out on its biology, life table and predation capacity on a number of greenhouse pests (Chyzik *et al.*, 1995; Gocuzzo *et al.*, 1997; Sanchez and Lacasa, 2002). However, less attention has been paid to comparison of the predation responses of *O. albidipennis* between different host plants and its effect on the predator-prey interactions. Thus, main objective of the present study was to assess the functional response of *O. albidipennis* females to densities of TSSM on strawberry and cucumber plants that differ in the physical appearance of the leaves in order to clarify predator-prey-plant interaction.

## MATERIALS AND METHODS

### Source of Predator, Prey and Host Plant

Stock colonies of *Orius albidipennis* were collected from an experimental corn farm of the Tehran University in Karaj, Tehran province in July 2007. They were maintained at  $25 \pm 1^\circ\text{C}$ ,  $65 \pm 5\%$  relative humidity (R. H.) and a 16 : 8 h L : D photoperiod and reared using Van der Meiracker's method (1994). The predatory bugs were fed with eggs of the flour moth, *Ephestia kuehniella* Zeller and corn pollen. Bean pods were provided for predator oviposition and crumpled tissue papers were

included to reduce predator contact, consequently reducing cannibalism. TSSM used in the experiments were obtained from the ecology laboratory of Tehran University and maintained on green bean (*Phaseolus vulgaris* L.) grown in plastic pots at  $24 \pm 1^\circ\text{C}$ , 70% R. H. and a 14 : 10 h L : D photoperiod.

The leaf discs used in the test arenas originated from strawberry (*Fragaria ananassa* W., cv. Selva) and cucumber (*Cucumis sativus* L., cv. Super Dominus) plants.

### General Experimental Conditions

The experimental arenas consisted of leaf discs (5 cm diameter) from freshly excised cucumber or strawberry leaves, placed upside down on the moist filter paper in a plastic container (70 mm diameter and 60 mm volume) ventilated through a hole in the lid. Before each experiment, mature predator females (5-day old) were fed with the test prey and then starved for 24 h in Petri dishes. All experiments were conducted at  $25 \pm 1^\circ\text{C}$ ,  $70 \pm 5\%$  R. H. and 16 : 8 h L : D photoperiod.

### Functional Response Experiments

To measure predation response of *O. albidipennis*, predator females were exposed to varying densities (5, 10, 20, 40 and 60) of either TSSM egg or female on single leaf discs in the presence of TSSM web produced by females for 24 h before the start of experiments. In TSSM egg experiment, eggs were transferred to the experimental unit by a fine camel's hair brush. Furthermore, eggs produced by females were removed from each leaf disc during TSSM female experiment (Hosseini *et al.*, 2005). Twelve replicates were tested at lower densities (5, 10 and 20), while eight replicates were tested at higher densities (40 and 60). The number of consumed prey was counted after 24 and 8 h for egg and female of TSSM, respectively.

### Data Analyses

The type of functional response (type II or ?) was determined using logistic regression analysis of the proportion of prey killed in relation to the initial density (Trexler *et al.*, 1988; Trexler and Travis, 1993).

In the logistic regression, a cubic model (Eq. 1) as under was incorporated :



$$N_e/N_0 = \frac{\exp (P_0 + P_1 N_0 + P_2 N_0^2 + P_3 N_0^3 + P_4 N_0^4)}{1 + \exp (P_0 + P_1 N_0 + P_2 N_0^2 + P_3 N_0^3 + P_4 N_0^4)} \quad \dots(1)$$

Where,  $N_e$  denotes the number of prey consumed,  $N_0$  the initial prey density and  $P_0$ ,  $P_1$ , the parameters to be estimated. A negative linear parameter  $P_1$  indicates a type II functional response, while a positive linear parameter indicates density dependent predation and thus a type III functional response (Juliano, 1993).

To estimate handling time ( $T_h$ ) and attack rates ( $a$ ) we used the Holling 'disc equation' for type II response and the Hassell equation for type III response. In both cases, depletion as predators fed is taken into account. Thus, following integral of the 'random predator' equation (Eq. 2, Rogers, 1972) for type II responses and the integral Hassell equation (Eq. 3) for type III responses were used:

$$N_e = N_0 \{1 - \exp [a(T_h N_e - T)]\} \quad \dots(2)$$

$$N_e = N_0 \frac{1 - \exp[(d + bN_0)(T_h N_e - T)]}{-(1 + cN_0)} \quad \dots(3)$$

Where,  $T$  denotes the total time available for search and  $T_h$  the handling time;  $b$ ,  $c$  and  $d$  are constants from the function that relates the attack rates ( $a$ ) and  $N_0$  in type III functional responses (Eq. 4, Hassell, 1978) is shown as under:

$$a = \frac{(d + bN_0)}{(1 + cN_0)} \quad \dots(4)$$

Parameters were obtained by fitting observed data to the models above using non-linear least-square regression with iterative application of Newton's method.

To examine the influence of host plant, prey stage and density, and their interactions on predation of TSSM by *O. albidipennis*, three-way analysis of variance (ANOVA) was used. In addition, a least significant difference (LSD) test was performed to determine differences between treatment means.

## RESULTS AND DISCUSSION

Predation responses of *O. albidipennis* to its prey on different plants are depicted in

Fig. 1. The logistic regression analysis showed that female predators exhibited a type II functional response in their predation of TSSM female on cucumber and strawberry as the linear term in the polynomial function describing the proportion of prey eaten in relation to density was negative. However, the positive linear term of *O. albidipennis* females on TSSM egg suggested type III response for them on cucumber and strawberry.

Attack rates ( $a$ ) of *O. albidipennis* on both cucumber and strawberry for TSSM female were estimated by the random predator equation to be 0.031 and 0.047, respectively (Fig. 1). However, on TSSM egg attack rate of predatory bugs was a function of prey density, with  $b$  averaging 0.001 and 0.004 for cucumber and strawberry, respectively. Since,  $a = b N_0$ , parameter  $a$  for cucumber and strawberry ranges from 0.005 to 0.06 and 0.02 to 0.24, respectively (Fig. 1). Handling times of *O. albidipennis* for TSSM egg and female on strawberry were shorter than those on cucumber. Moreover, the expected maximum consumption ( $T/T_h$ ) of *O. albidipennis* for TSSM egg (9.8) and female (9.4) on strawberry was higher than that for egg (3.4) and female (3.15) of TSSM on cucumber. Three-way factorial ANOVA indicated that host plant, prey density and interaction of host plant  $\times$  prey stage  $\times$  prey density effects on the consumption of *O. albidipennis* were significant (Fig. 1). Thus, predators did not perform similarly at different densities of prey stages on host plants. The mean number of TSSM egg consumed by the predatory bugs on strawberry was greater than that on cucumber at all prey densities (Fig. 1). A same trend was observed in consumption of TSSM female at low and intermediate prey densities (5, 15 and 20 mites per leaf disc), where the mean consumption on strawberry was higher than that on cucumber. However, at the higher prey densities (40 and 60 mites per leaf disc) the mean consumption of TSSM female by *O. albidipennis* on cucumber was higher than that on strawberry (Fig. 1).

Minute pirate bugs showed similar type of functional response to TSSM on both cucumber and strawberry, and their predation followed type II and III on female and egg, respectively. A type II functional response for *Orius* species has been reported for varying prey items, such as *O. albidipennis* on *Megatriethrips sjostedti* Trybom (Gilonga et al., 2002), *O.*



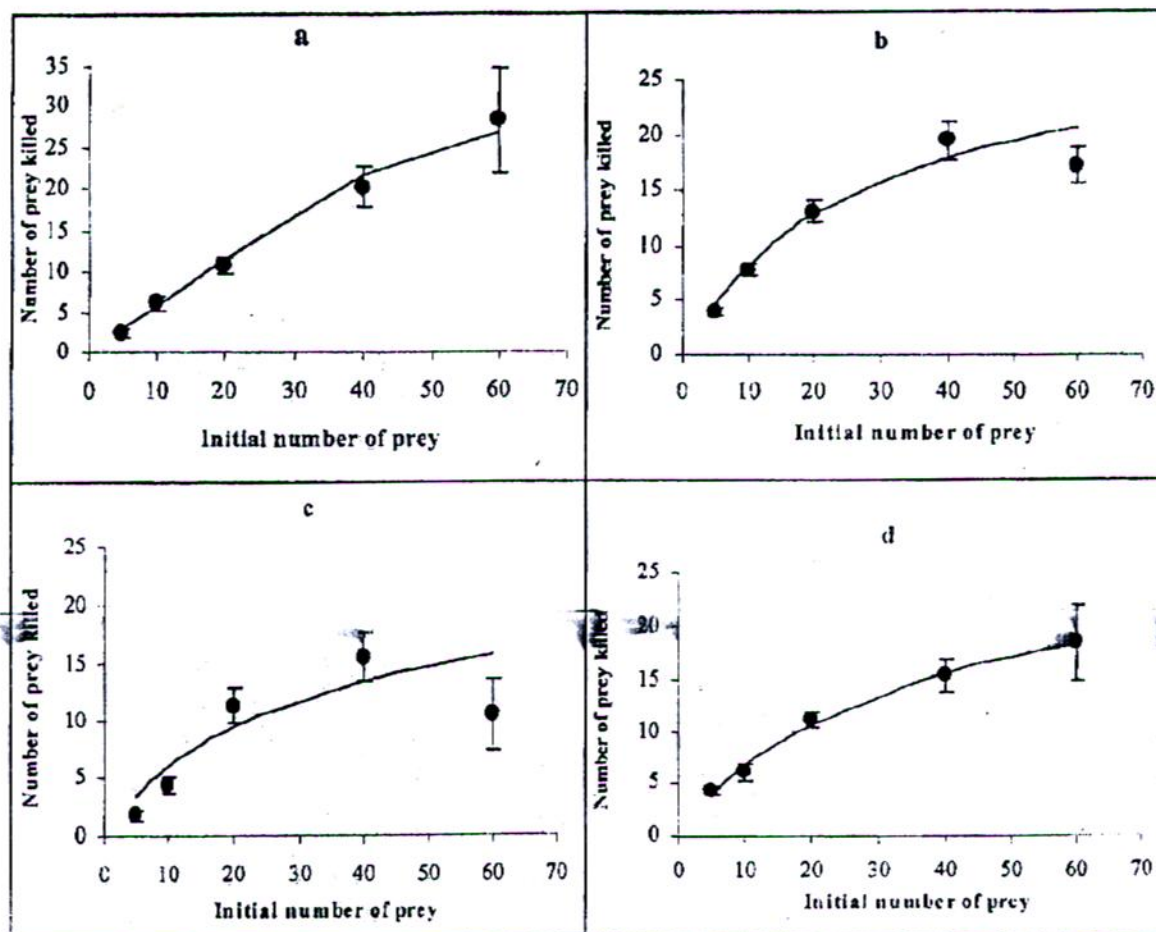


Fig. 1. Observed numbers (symbols) of TSSM egg and female killed by *O. albidipennis* female versus numbers predicted by the random predator equations (lines) on strawberry and cucumber leaves: (a) TSSM egg on strawberry, (b) TSSM female on strawberry, (c) TSSM egg on cucumber and (d) TSSM adult on cucumber.

*majusculus* (Reuter) and *O. laevigatus* (Fieber) on *Frankliniella occidentalis* (Montserrat *et al.*, 2000) and *O. insidiosus* (Say) on TSSM and *Aphis glycines* Matsumura (Van den Meiracker and Sabelis, 1999; Rutledge and O'Neil, 2005). However, to our knowledge, this study is the first report of type III functional response for *Orius* predatory bug on egg of TSSM. The type III response was originally considered characteristic of vertebrate predators, whereas a type II response was thought to be shown by invertebrate predators and parasitoids (Holling, 1959). However, a number of invertebrate predators and parasitoids, if presented with cryptic, relatively small and immobile prey, showed a type III response (Hassell *et al.*, 1977; Stream, 1994). Such a behaviour denoted situation that predator searching reduced when

the rate of prey encounter fell below a threshold level and raised as prey density increased because predator learnt how to circumvent some difficulty associated to catching the prey (Hassell, 1978; Schenk and Bacher, 2002). It seems, therefore, a type III response for *O. albidipennis* could be induced by the much smaller size and immobility of TSSM egg at low and medium densities of prey.

In the present study, although predators had the same type of functional response to egg and female of TSSM on both host plants, they presented lower searching efficiencies and higher handling times for TSSM female and egg on cucumber than those on strawberry. Further, the maximum number of prey attacked by *O. albidipennis*, given by the asymptote ( $T/T_h$ ) of the functional response



curve, was greater on strawberry than on cucumber. Lower maximum predation and longer handling time of the predatory bugs on cucumber could be attributed to the significantly more dense trichomes covering the surfaces of cucumber leaves than that of strawberry leaves (Mahr *et al.*, 2001), which mechanically impeded the predator's movement and encounter rate. It is well known that host plant traits such as leaf hairs and trichomes can diminish the searching of predators not only by hindering their movement and encounter rate but also with providing more refuges for prey (Price *et al.*, 1980; Walter and O'Dowd, 1992; Skirvin and Fenlon, 2001; Stavrinides and Skirvin, 2003). Our results are in accordance with those of Shipp and Whitfield (1991), who found that the predation efficiency of *Amblyseius cucumeris* (Oudemans) on the thrips *Frankliniella occidentalis* (Pergande) was higher on sweet pepper than that on cucumber leaves due to differences in trichome densities on the two host plants. Similarly, in studies with *O. albidipennis*, Wang and Shumilov (1996) observed that whereas the leaves of tomato and pepper did not interfere with consumption of thrips by the predatory bugs, predator consumption on thrips significantly lessened on cucumber leaves. The authors concluded that the dense trichome covered surface of cucumber leaves could have lessened movement of predatory bugs, thereby interfering with capture of thrips.

Although, trichome density of the host plants may not be the only possibility for the results obtained in this study, there is no evidence that differences in the chemical properties of the host plant species influenced the searching capabilities of *O. albidipennis*. Predatory bugs not only show significant preference for compounds induced by feeding of TSSM (HIPVs) on cucumber compared to that on strawberry but also inherent compounds of these plants have the same effect on attraction of *O. albidipennis* (Karimi *et al.*, 2006).

The present study has improved our understanding of the two-host plants-TSSM-*O. albidipennis* interactions under laboratory conditions. Together with the fact that the intrinsic rate of increase for TSSM on cucumber is the same as on strawberry (Azadeh Karimi, personal communication), our results

on strawberry than on cucumber. Our findings agree with the results of Mahr *et al.* (2001) who found that *O. laevigatus* and *O. albidipennis* were able to control western flower thrips on strawberry, but not on cucumber, due to the absence of pollen and the numerous trichome on the cucumber leaves which inhibit movement and searching of the predators (Mahr *et al.*, 2001).

Though our small-scale laboratory experiments of *O. albidipennis* predation may not exactly correspond to the field condition, this could have some values as a first step in evaluating host plant morphological feature effects on predation capacity of *O. albidipennis* as a biological control agent of TSSM. We recommended that to develop a biological control programme for TSSM using *O. albidipennis*, more realistic field experiments are needed to elucidate tritrophic relationships among *Orius* bugs, their prey and host plants.

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