2011 International Conference on Food Engineering and Biotechnology
IPCBEE vol.9 (2011) © (2011)IACSIT Press, Singapore

Functional response of Orius niger niger (Hemiptera: Anthocoridae) to Tetranychus urticae (Acari: Tetranychidae): effect of host plant morphological feature

Alireza Jalalizand[1+], Mehrdad Modaresi[2], Seyed Ali Tabeidian[2], Azadeh Karimy[1] .

1- Department of plant Protection, Islamic Azad University-Khorasgan Branch , Isfahan , IRAN

2- Department of Animal Science, Islamic Azad University-Khorasgan Branch , Isfahan , IRAN

Abstract. Effect of host plant on the functional response of *Orius niger niger* 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* was examined over 24 and 8 h periods, respectively. Logistic regression analysis revealed that *O.* niger *niger* 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 0.021 and 0.045 h"[1], respectively. Moreover, attack coefficient *b,* which describes the changes in attack rate with prey densities in a type **III** response *(a = b N),* of *O. niger niger* to *T. urticae* eggs on cucumber and strawberry was 0.001 and 0.003 h"[1], 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 0.80 vs.0.98 and 0.82 vs. 0.70 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.

Keywords: Orius niger niger, Host plant, Functional response, Tetranychus urticae, Tritrophic interaction, biological control

1. Introduction

The functional response of a predator is a key factor regulating the population dynamics of predator-prey systems. It describes the rate at which a predator kills its prey at different prey densities and can thus determine the efficiency of a predator in regulating prey populations (18). 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 (6 , 7). This phenomenon is not only mediated by predator-prey interactions, but is also affected by host plant characteristics (3). 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(14,16,20). Several studies have shown simple changes in plant morphology can hinder the searching ability of natural enemies by mechanically hindering the movement of predators and parasites (4,25,26). As searching ability is a major factor in determining the functional response of natural enemies, altered searching efficiency caused by variations in plant morphology could also affect predator functional response (2,5,11,12,24)

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. These crops are constantly infested by two-spotted spider mite, *Tetranychus urticae* Koch (Acari: Tetranychidae) (TSSM) (1,27), but those are prone for biological of control

TSSM because of naturally occurring predatory species such as the minute pirate bug *Orius niger niger* (Hemiptera: Anthocoripresent study was to assess the functional response of *O. niger niger* 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.

2. Materials and methods

2.1. Source of predator, prey and host plant: Stock colonies of *Orius niger niger* were collected from alfalfa farms of the Isfahan province in summer 2009. They were maintained at 25 ± 1 °C, 65 ± 5 % relative humidity (r. h.) and a 16:8 h L:D photoperiod and reared using Van den 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 greenhouse of Khorasgan azad University and maintained on green bean *(Phaseolus vulgari* L) grown in plastic pots at 24 ± 1 °C, 70 ± 5 % r.h. and a 14:10 h L:D photoperiod.

2.2. General experimental conditions: The experimental arenas consisted of leaf disks (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 24h in Petri dishes. All experiments were conducted at 25 ± 1°C, 70 ± 5 % r.h. and 16:8 h L:D photoperiod.

2.3. Functional response experiments: To measure predation response of *O. niger niger,* predator females were exposed to varying densities (5, 10, 20, 40 and 60) of either TSSM egg or female on single leaf disks 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 disk during TSSM female experiment (8). 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.

2.4. Data analyses: The type of functional response (type II or III) was determined using logistic regression analysis of the proportion of prey killed in relation to the initial density (29&30)

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

$$(1)\quad Ne \Big/ N_0 = \frac{\exp\left(P_0 + P_1N_0 + P_2N_0^2 + P_3N_0^3 + P_4N_0^4\right)}{1+\exp\left(P_0 + P_1N_0 + P_2N_0^2 + P_3N_0^3 + P_4N_0^4\right)}$$

Where N_e denotes the number of prey consumed, N_o the initial prey density and P_o- P_4 the parameters to

be estimated. A negative linear parameter *Pi* indicates a type II functional response, while a positive linear parameter indicates density dependent predation and thus a type III functional response (9).

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, we used the integral of the 'random predator' equation (Eq. 2, Rogers 1972) for type II response: (2) $Ne = N_0\ \{1\text{-exp}\ [a(T_hNe - T)]\}$ and the integral Hassell equation (Eq. 3) for type III responses: (3) $Ne = N_0 \frac{1-\exp[(d+bN_0)(ThNe-T)]}{(1+cN_0)}$ 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_o in type III functional responses (6): (4) $a = \frac{(d+bN_0)}{(1+cN_0)}$ Parameters were obtained by fitting observed data to the models above using nonlinear least-square regression with iterative application of Newton's method (PROC NLIN, SAS 2001).

To examine the influence of host plant, prey stage and density, and their interactions on predation of TSSM by *O. niger niger*, three-way analysis of variance (ANOVA), was used. In addition, a least significant difference (LSD) test was performed to determine differences between treatment means (SAS 2001).

3. Results

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. Also, the positive linear term of *O. niger niger* females on TSSM egg suggested type III response for them on cucumber and strawberry.

Attack rates (a) of *O. niger niger* on both cucumber and strawberry for TSSM female were estimated by the random predator equation to be 0.021 and 0.045, respectively. However, on TSSM egg attack rate of predatory bugs was a function of prey density, with *b* averaging 0.001 and 0.003 for cucumber and strawberry, respectively. Handling times of *O. niger niger* for TSSM egg and female on strawberry were shorter than those on cucumber. Three-way factorial ANOVA indicated that host plant, prey density and interaction of host plant xprey stage x prey density effects on the consumption of *O. niger niger* were significant. 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. A same trend was observed in consumption of TSSM female at low and intermediate prey densities.

4. Discussion

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 response was thought to be shown by invertebrate predators and parasitoids (7). 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 (7). However, a number of invertebrate predators and parasitoids, if presented with cryptic, relatively small and immobile prey, show a type III response (6,27). Such a behaviour denoted situation that predator searching reduces when the rate of prey encounter falls bellow a threshold level and raises as prey density increasing because predator learn how to circumvent some difficulty associated to catching the prey (6,23). It seems, therefore, a type III response for *O. albidipennis* could be induce 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. niger niger,* given by the asymptote *(TI* 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 attribute to the significantly more dense trichomes covering the surfaces of cucumber leaves than that of strawberry leaves (13), 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 (20,24). Our results are in accordance with 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 *Orius insidiosus,* Ferguson and Schmidt (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.

5. References

[1] Arbabi M (2007) Study on effectiveness of *Phytoseiulus persimilis* in control of cucumber two spotted spider mite *(Tetranychus urticae* complex) in woody and iron greenhouse structures in Varamine region. Pajouhesh and Sazandegi 73: 96-104 (In Persian with English abstract).

[2] Cedola CV, Sanchez NE, Lilijesthrom GG (2001) Effect of tomato leaf hairiness on functional and numerical response of *Neoseiulus californicus* (Acari: Phytoseiidae). Exp Appl Acarol 25:819-831.

[3] Coll M, Ridgway RL (1995) Functional and numerical responses of *Orius insidiosus* (Heteroptera: Anthocoridae) to its prey in different vegetable crops. Ann Entomol Soc Am 88:732-738.

[4] Croft P, Fenlon J, Jacobson RJ, Dubas J (1999) Effect of tomato conditioning on *Phytoseiulus persimilis* Athias-Henriot (Acari: Phytoseiidae) population growth. IOBC/WPRS Bull 22:45-48.

[5] De Clercq P, Mohaghegh J, Tirry L (2000) Effect of host on the functional response of the predator *Podisus nigrispinus* (Heteroptera: Pentatomidae). Biol control 18:65-70.

[6] Hassell MP (1978) The dynamics of arthropod predator-prey systems. Princeton Univ. Press, Princeton .

[7] Holling CS (1959) The components of predation as revealed by study of small-mammal predation of the European pine sawfly. Can Entomol 91:239-320.

[8] Hosseini M, Hatami B, Saboori A, allahyari H, Ashouri A (2005) Predation by *Allothrombium pulvinum* on the spider mites *Tetranychus urticae* and *Amphitetranychus viennensis*: predation rate, prey preference and functional response. Exp Appl Acarol 37:173–181.

[9] Juliano SA (1993) Nonlinear curve fitting: predation and functional response curves. In: Scheiner SM, Gurevitch J (Eds), Design and Analysis of Ecological Experiments. Chapman and Hall, New York, pp 159-182.

[10] Karimy A, Ashouri A, Kharazi Pakdel A, Goldansaz SH, Kosari AA, Moayeri HR (2006) Olfactory response of the predatory bug, *Orius albidipennis* to volatile blends of strawberry and cucumber infested by spider mite. Commun Agric Appl Biol Sci 71:399-402 .

[11] Koveos DS, Broufas GD (2000) Functional response of *Euseius finlandicus* and *Amblyseius undersoni* to *Panonychus ulmi* on apple and peach leaves in the laboratory. Exp Appl Acarol 24:247-256.

[12] Madadi H, Enkeggard A, Brodsggard HF, Kharrazi-Pakdel A, Mohaghegh J, Ashouri A (2007) Host plant effects on the functional response of *Neoseiulus cucumeris* to onion thrips larvae. J Appl Entomol 131:728-733.

[13] Mahr SE, Cloyd RA, Mahr D, Sadof CS (2001) Biological control of insects and other pest of greenhouse crops. Wisconsin Univ. Press, Wisconsin.

[14] .Messina FJ, Hanks JB (1998) Host plant alters the shape of the functional response of an aphid predator (Coleoptera: Coccinellidae). Environ Entomol 27:1196-1202 .

[15] Moayeri HRS, Ashouri A, Brødsgaard HF, Enkegaard A (2006a) Odour-mediated responses of the predatory mirid bug, *Macrolophus caliginosus* Wagner (Heteroptera: Miridae) and its prey, the two-spotted spider mite, *Tetranychus urticae* Koch (Acari: Tetranychidae). Exp Appl Acarol 40:27-36.

[16] Moayeri HRS, Ashouri A, Brødsgaard HF, Enkegaard A (2006b) Odour-mediated preference and prey preference of *Macrolophus caliginosus* between spider mites and green peach aphids. J Appl Entomol 130:504-508.

[17] Montserrat M, Albajes R, Castane C (2000) Functional response of four heteropteran predators preying on greenhouse whitefly (Homoptera: Aleyrodidae) and western flower thrips (Thysanoptera:Thripidae). Environ Entomol 29:1075–1082. 5

[18] Murdoch WW, Oaten A (1975) Predation and population stability. Adv Eco Res 9: 1-131.

[19] Ostovan H, Mirhelli A (2005) Flower bugs of the genus *Orius* Wolff (Heteroptera: Anthocoridae) from Iran and feeding rate of predatory bug *Orius albidipennis* (Reuter) under laboratory conditions. IOBC/WPRS Bull 28:195-197.

[20] Price PW, Bouton CE, Gross P, Mcpheron BA, Thompson JN, Weis AE (1980) Interaction among three trophic levels: Influence of plants on interaction between insect herbivores and natural enemies. Annu Rev Ecol Syst 11:41-65.

[21] Rogers DJ (1972) Random search and insect population models. J Anim Ecol 41: 369-383.

[22] Rutledge CE, O'Neil RJ (2005) *Orius insidiosus* (Say) as a predator of the soybean aphid, *Aphis glycines* Matsumura. Biol Control 33:56-64.

[23] Schenk D, Bacher S (2002) Functional response of a generalist predator to one of its prey species in the field. J Anim Ecol 71:524-531.

[24] Skirvin DJ, Fenlon JS (2001) Plant species modifies the functional response of *Phytoseiulus persimilis* (Acari: Phytoseiidae) to *Tetranychus urticae* (Acari: Tetranychidae): implications for biological control. Bull Entomol Res 91:61-67.

[25] Stavrinides MC, Skirvin DJ (2003) The effect of chrysanthemum leaf trichome density and prey spatial distribution on predation of *Tetranychus urticae* (Acari: Tetranychidae) by *Phytoseiulus persimilis* (Acari: Phytoseiidae). Bull Entomol Res 93:343-350.

[26] .Sütterlin S, Van Lenteren, JC (1997) Influence of hairiness of *Gerbera jamesonii* leaves on the searching efficiency of the parasitoid *Encarsia Formosa*. Biol Control 9: 157-165.

[27] Tehranifar A, Sarsaefi M (2002) Strawberry growing in Iran. Acta Hort 567:547-549.

[28] Thomasini M.G., Vanlenteren J. C., Burgio G. (2004) Biological traits and predation capacity of four *Orius* species on two prey species. *Bulletin of Insectology **57** (2): 79-93, 2004*.

[29] Trexler JC, Mc Culloch CE, Travis J (1988) How can the functional response best be determined? Oecologia 76:206-214.

[30] Trexler JC, Travis J (1993) Nontraditional regression analyses. Ecology 74:1629-1637.

[31] .Walter DE, O'Doed DJ (1992) Leaf morphology and predators: Effect of leaf domatia on the abundance of predatory mites (Acari: Phytoseiidae). Environ Entomol 21: 478-484.