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Effect of host plants on the functional response of the acarophagous ladybird beetle, *Stethorus gilvifrons* to *Tetranychus turkestani*

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Abstract

The strawberry spider mite, *Tetranychus turkestani* Ugarov and Nikolski, is an important pest of various field and glasshouse crops in Iran. This study aimed to determine the functional response of adult females of *Stethorus gilvifrons* Mulsant to different densities of *T. turkestani* on three fabaceous host plant species: cowpea (*Vigna unguiculata* L.), white bean (*Phaseolus lunatus* L.), and red bean (*Phaseolus calcaratus* Roxb.) at 30±2 °C, 60±10 % RH, and a photoperiod of 16L: 8D. Beetles were starved for 24 h before testing and then isolated singly for 24 h in 9-cm Petri dishes with 4, 8, 12, 24, 48, or 96 adult females of *T. turkestani*. Logistic regression analysis revealed a type III response on cowpeas. Constant (*b*) and handling time were 0.00718 and 0.3299 h, respectively. In contrast, a type II response was observed in white beans and red beans. The maximum attack ($0.1219\ h^{-1}$) and the minimum handling time (0.2301 h) were recorded on white beans and red beans, respectively. The maximum attack rates (*T/Th*) were 72.74, 60.42, and 104.30 eggs/day on cowpeas, white beans, and red beans, respectively. This laboratory study suggests that the plant features affect the capability of *S. gilvifrons* to respond to changes in a high *T. turkestani* density.

Keywords: Attack rate, Handling time, Fabaceae, Strawberry spider mite

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Introduction

The strawberry spider mite, *Tetranychus turkestani* Ugarov and Nikolski (*Tetranychus atlanticus* McGregor), is among the most important tetranychid pests in the world (Jeppson et al., 1975; Bolland et al., 1998). It is a polyphagous species that feeds on 25 plant species belonging to more than 15 plant families (Jeppson *et al*., 1975; Kamali et al., 2001; Modarres Awal, 2012). This phytophagous mite is distributed throughout the United States, Europe, Russia, Japan, China, the Near East, and the Middle Eastern countries (Jeppson et al., 1975; Helle and Sabelis, 1985; Zhang, 2003; Hoy, 2011).

In Khuzestan province, southwest of Iran, *T. turkestani* frequently attacks plant species belonging to the families, such as Solanaceae (Nemati et al., 2005), Fabaceae (Leguminosae) (Sohrabi and Shishehbor, 2008), and Cucurbitaceae (Karami Jamoor et al., 2012). The feeding activity of *T. turkestani* leads to the appearance of white chlorotic spots on the upper side of leaves with copious webbing underside the leaves. In serious infestations, leaves may drop, and flowering may be noticeably reduced. The short developmental period and high reproductive potential help the insect to have a fast-growing population, allowing the mite to incur economic losses in favorable conditions, resulting in a rapid decline of crop yields (Carey and Bradley, 1982; Tomczyk and Kropczynska, 1985; Sohrabi and Shishehbor, 2008; Karami Jamour *et al*., 2012).

Stethorus gilvifrons Mulsant (Coleoptera: Coccinellidae) is a coccinellid beetle native to Iran (Mossadegh and Kocheili, 1993) and several other countries in the east of Asia (McMurtry et al., 1970; Chazeau, 1985; Aksit et al., 2007). It is commonly found on field crops, such as sugarcane and castor bean (Afshari, 1999; Modarres Awal, 2012), and on fruit trees, such as apple, almond, cherry, pistachio, fig, apricot, lime trees, and date palms (Kohpayezadeh Isfahani and Mossadegh, 1993; Mossadegh and Kocheili, 1993; Mossadegh and Kocheili, 2003). *S. gilvifrons* has been validated as a good candidate for the biological control of numerous species of spider mites, including *T. turkestani* (Chazeau 1985; Biddinger et al., 2009; Hoy, 2011).

The performance of a predator depends on several characteristics, two of which are functional and numerical responses. The functional response describes the relationship between the number of preys attacked by an individual predator and prey density (Solomon, 1949). Several types of functional response have been described, including a linear increase (Type I), an increase decelerating to a plateau (type II), or a sigmoid increase (Type III) (Holling, 1959; Hassell et al., 1977). Arthropods feature type II and III responses, though type II is more frequent (Hassell, 1978).

The effect of host plant morphological characteristics on the predatory behavior of *Stethorus* species has been reported frequently (Putman, 1955; Riddick et al., 2011; Riddick and Wu, 2011). The information on the impact of Fabaceae host plants on the functional response of *S. gilvifrons* to *T. turkestani* is limited. In fact, the only documented report was that of Karami Jamour and Shishehbor (2012), who reported that the functional response of *S. gilvifrons* on *T. turkestani* varied among three Fabaceae plant species (cowpea, green gram, and pinto bean). To further quantify the influence of host plants on the predatory characteristics of *S. gilvifrons*, we determined the functional response of adult females to different densities of *T. turkestani* on three Fabaceae host plant species.

Materials and methods

Plant materials

Three plant species of Fabaceae were used in this study: cowpea (*Vigna unguiculata* L.), white bean (*Phaseolus lunatus* L.), and red bean (*Phaseolus calcaratus* Roxb.). Seeds were purchased from a local grocery store and planted in plastic pots (20 cm diameter, 10 cm height) in a mixture of compost (Nutrifood Company, Iran) and sawdust (1:1 ratio) and kept in wooden cages ($120 \times 60 \times 60$ cm^3) covered by a white nylon mesh (with apertures of 120 µm). The plants were maintained in the laboratory at 30±2 °C, 65± 5% RH, and 16:8 (L:D) with illumination (4000 lux) provided by fluorescent lamps. The plants were watered every three days, and fertilizer (Hortigrow, Netherland) was added to the water. Studies were initiated when cowpeas, white beans, and red beans were three, four, and four weeks old, respectively. The heights of the above plants at these ages were ≈ 30, 25, and 25 cm for cowpeas, white beans, and red beans, respectively. Only the second to fourth fully expanded leaves (from the growing terminal) were selected.

Spider mite colony

Tetranychus turkestani was collected from morning glory (*Convolvulus arvensis* L.) leaves grown in the vicinity of the Shahid Chamran University of Ahvaz, Ahvaz, Iran (31° 20´ N, 48° 40´ E) in November 2018 and used to start rearing the colony. This stock colony was separately maintained on cowpea, white bean, and red bean plants. The infested plants were kept in wooden framed cages under the laboratory conditions described above. The plants were maintained until they were severely damaged by the spider mites. Also, new plants were added when necessary.

S. gilvifrons colony

Stethorus gilvifrons were collected from hollyhock (*Altha officinalis* L.) leaves grown in the vicinity of Shahid Chamran University of Ahvaz, Ahvaz, Iran, in April 2018 and were used to establish a stock colony. The colony was maintained in the above-mentioned wooden rearing cages using all stages of *T. turkestani* as a food source on cowpea plants in the laboratory. New *T. turkestani*-infested cowpea plants were added to the cages every week. The laboratory conditions were similar to those described above. The experiments were carried out at the Department of Plant Protection, Shahid Chamran University of Ahvaz, Ahvaz, Iran.

The leaves of cowpea, white bean, and red bean were used as substrates. The experimental arena consisted of a plastic petri dish (9 cm in diameter), the lid of which was covered with a fine mesh screen. Each petri dish was prepared by placing a leaf (upside down) of the respected plant on a wet cotton pad of the same size at the bottom of the petri dish. Adult female strawberry spider mites (n=4, 8, 12, 24, 48, or 96) were placed on the leaves using a fine paintbrush. These densities were selected based on the preliminary tests on the consumption capacity of different stages of *S. gilvifrons.* A single female *S. gilvifrons* (approximately two weeks old), starved for 24 h before testing, was introduced into each petri dish. Ten replications of each density were set up simultaneously. the experiments lasted for 24 h in a growth chamber at 30±2 °C, 65±5 % RH, and 16: 8 (L:D), after which the beetles were removed, and the total number of consumed prey was counted. If the mite bodies were shrunk, discolored, or immobile, they would be registered as a consumed prey. Observations were made with a stereomicroscope.

The trichome numbers in the lower surface of plant species were counted using a dissecting microscope (Olympus Co, Japan) at 40X magnification. Trichomes were counted in an area of 1.0 mm^2 from different parts of each leaf.

Data analysis

A two-way factorial analysis of variance (ANOVA) and Tukey's honestly significant difference (HSD) tests (P <0.05) were used to analyze the data for significant differences in the number of consumed prey and number of trichomes among the tested plant species (SAS Institute 2012).

The logistic regression of the proportion of the prey consumed as a function of initial prey density was used to determine the type of the functional response curve of *S. gilvifrons* for different densities of *T. turkestani* on different host plant species:

$$\frac{N_a}{N_0} = \frac{\exp\ (P_0 + P_1 N_0 + P_2 N_0^2 + P_3 N_0^3)}{1 + \exp\ (P_0 + P_1 N_0 + P_2 N_0^2 + P_3 N_0^3)}$$

where N_a is the number of prey consumed, N_0 is the initial prey density, (N_a/ N_0) is the probability of prey consumption, and P_0, P_1, P_2, and P_3 are the estimated maximum likelihood of the constant, linear, quadratic, and cubic coefficients, respectively, related to the curve slope (Juliano, 2001). If the linear parameter P_1 is negative, a type II functional response will be evident, whereas P_1 is positive and P_2 is negative, and a type III response is evident (Juliano, 2001). After determining the type of functional response, the attack rate (a) and handling time (T_h) coefficients were estimated (a nonlinear least-squares regression (PROC NLIN)). In the current study, we used an explicit deterministic model for type II functional response (Rogers, 1972):

$$N_a = N_0[1 - \exp(a(T_h N_a - T))] \quad (2)$$

where N_a is the number of prey killed, N_0 is the initial prey density, T is the total time that predator and prey are exposed to each other (24 h), a is the attack rate, and T_h is the handling time. For the type III functional response, in the simplest generalized form, the attack rate (equation 3) is a function of the initial quantity of prey:

$$a = (d + bN_0)/(1 + cN_0) \quad (3)$$

where b, c, and d are constants that must be estimated. The simplest form arises when a is a function of the initial density as in equation 4:

$$N_a = N_0\{1 - \exp[(d + bN_0)(\mathrm{T_h N_a} - \mathrm{T})(1 - \mathrm{cN_0})]\} \quad (4)$$

Then, for each host density, the attack rate coefficient (a) can be determined as $a = bN_0$. An iterative nonlinear least square regression (NLIN procedure, SAS Institute, 2012) was used to fit the random predator equation to the data to estimate the parameters describing the type II functional response. Likewise, a nonlinear least square regression procedure was used to fit the related equation to the data generating a type III functional response.

The parameters D_{Th} and D_a show differences between the two groups with the same functional response type in handling times and attack rates, respectively. After analysis using an indicator variable method as follows (Juliano, 2001; Farhadi et al., 2010; Zarghami et al., 2016):

$$N_a = \{1 - \exp[-(a + D_a(j))(T - (T_h + D_{Th}(j))N_a)]\}$$

Where j is an indicator variable that takes on a value of 0 for the first data set and 1 for the second data set. Testing the null hypothesis in that $Da = 0$ reveals the significance of differences in searching efficiencies between the two stages (Juliano, 2001, Allahyari et al., 2004; Farhadi et al., 2010; Zarghami et al., 2016). The coefficient of determination was calculated according to the following formula (Allahyari et al., 2004):

$$r^2 = 1 - \text{residual sum of squares/corrected total sum of squares}$$

Results

The prey density and host plant had a significant effect on the mean number of the prey consumed (prey density: F= 223.62; df= 5, 153; $P < 0.0001$; host plant: F= 10.57; df=2, 153; $P < 0.0001$), as did the prey density × host plant interaction (F= 3.54; df= 10, 153; $P = 0.0003$) indicated that the effect of prey density treatment on the mean number of the prey consumed was affected by the host plant (Table 1).

The plant species evaluated in this work significantly varied in the density of trichomes (F= 17.92; df= 2, 44; $P < 0.0001$). If arranged in descending order, the plants with higher trichome density were white beans (42.93±7.45), red beans (29.86±4.76), and cowpeas (0.66±0.23). The results indicated that *S. gilvifrons* could consume more adult female *T. turkestani* on cowpeas than on white beans and red beans. In prey densities below 24, there was a small difference in the mean number of the prey consumed on the three host plants; however, the differences in the mean number of the prey consumed only became apparent at higher prey densities (Table 1). At the highest density of 128 adult females, the consumption rate was approximately 20 and 30 % higher on cowpeas than on red beans and white beans, respectively.

Functional response curves of *S. gilvifrons* on different host plant species are shown in Figures 1 & 2. Logistic regression analysis (Table 2) indicated a type II functional response on red beans and white beans but a type III response on cowpeas.

The results indicated that despite similar functional responses of *S. gilvirons* feeding on different densities of adult female *T. turkestani* on white beans and red beans (Type II functional response), the attack rate and handling

Table 1. Mean (±SE) (Range) of *Tetranychus turkestani* adults attacked by *Stethorus gilvifrons* adult females on leaf with different prey density over a 24-h period at 30±°C.

Prey density	Cowpea	White bean	Red bean	*F*	*df*	*P*
4	3.91 ± 0.1^{Da}	3.8 ± 0.13^{Da}	3.7 ± 0.15^{Da}	0.58	2	0.56
8	8.00 ± 0.1^{Da}	7.5 ± 0.26^{Dab}	7.2 ± 0.24^{CDb}	3.64	2	0.04
12	11.5 ± 0.3^{Da}	11.7 ± 0.15^{Da}	11.4 ± 0.22^{CDa}	0.42	2	0.66
24	23.7 ± 0.21^{Ca}	21.0 ± 0.85^{Ca}	17.4 ± 1.28^{Cb}	11.79	2	<0.0001
48	42.0 ± 1.46^{Ba}	33.7 ± 1.23^{Bb}	32.1 ± 1.26^{Bb}	16.05	2	<0.0001
96	67.6 ± 3.03^{Aa}	46.9 ± 4.73^{Ab}	53.5 ± 6.48^{ABb}	3.52	2	<0.0001
F	126.97	67.59	46.41			
df	5	5	5			
P	<0.0001	<0.0001	<0.0001			

Means within columns and rows followed by the same letters are not significantly different ($P < 0.05$). Upper case letters are used to compare the effects of different densities on the same host plant; lowercase letters are used to compare effects of different host plants on the same prey density.

time parameters were significantly different on the two host plants (Tables 3 and 4).

For cowpeas, the relationships between the attack rate and the initial number of preys were linear ($a=bN_0$), and the rate of successful attack (a) for densities of 4, 8, 12, 24, 48, and 96 were 0.0287, 0.0574, 0.0861, 0.1723, 0.3446, and 0.6893, respectively. According to the handling time estimation, the maximum number of *T. turkestani* adult females that a single female of *S. gilvifrons* can predate is 60.42, 72.74, and 104.30 on the white bean, cowpea, and red bean as a host plant, respectively (Table 3).

Discussion

Variable results have been reported regarding the type of functional response of *S. gilvifrons* feeding on different tetranychid mites. Type III functional response of *S. gilvifrons* was reported by Hajizadeh et al. (1993) on *Panonychus ulmi* (Koch) and by Sohrabi and Shishehbor (2007) on *T. turkestani*, which are in agreement with our findings on cowpea. Furthermore, other studies have also shown a type II functional response of *S. gilvifrons* to variations in densities of its prey, including *Oligonychus sacchari* McGregor (Afshari, 1999), *Tetranychus urticae* Koch (Mehr-Khou, 2006), *Oligonychus afrasiaticus* McGregor (Matin, 2007), *Eutetranychus orientalis* Klein (Imani et al., 2010) and *T. turkestani* (Karami Jamour and Shishehbor, 2012) which are similar to our results on white bean and red bean.

Holling (1965) reports that only predators exhibiting a type III functional response can regulate their prey populations because only this type of response will pave the way for long-term persistence. However, it should be noted that although the functional response is a significant aspect of natural enemy behavior, it is not the sole factor determining the effectiveness of a biological control agent. Other aspects, including numerical response, high intrinsic rate of population increase, high searching efficiency (Hassell, 1978), prey stage (Haque et al., 2010), age of natural enemy (Li et al., 2007), generation of a natural enemy (Khanamani et al., 2017), host plant characteristics (Cedola *et al.*, 2001; Skirvin and Fenlon, 2001; Prevez and Omkar, 2005; Ahn et al., 2010; Gontijo et al., 2012; Karami Jamour and Shishehbor, 2012), and abiotic environmental factors, such as temperature (Skirvin and Fenlon, 2003) can also affect the efficiency of predators. Although the only factor of the host plant species evaluated in the current study was trichome density, it is well-known that predatory effectiveness is affected by other plant traits. For instance, the

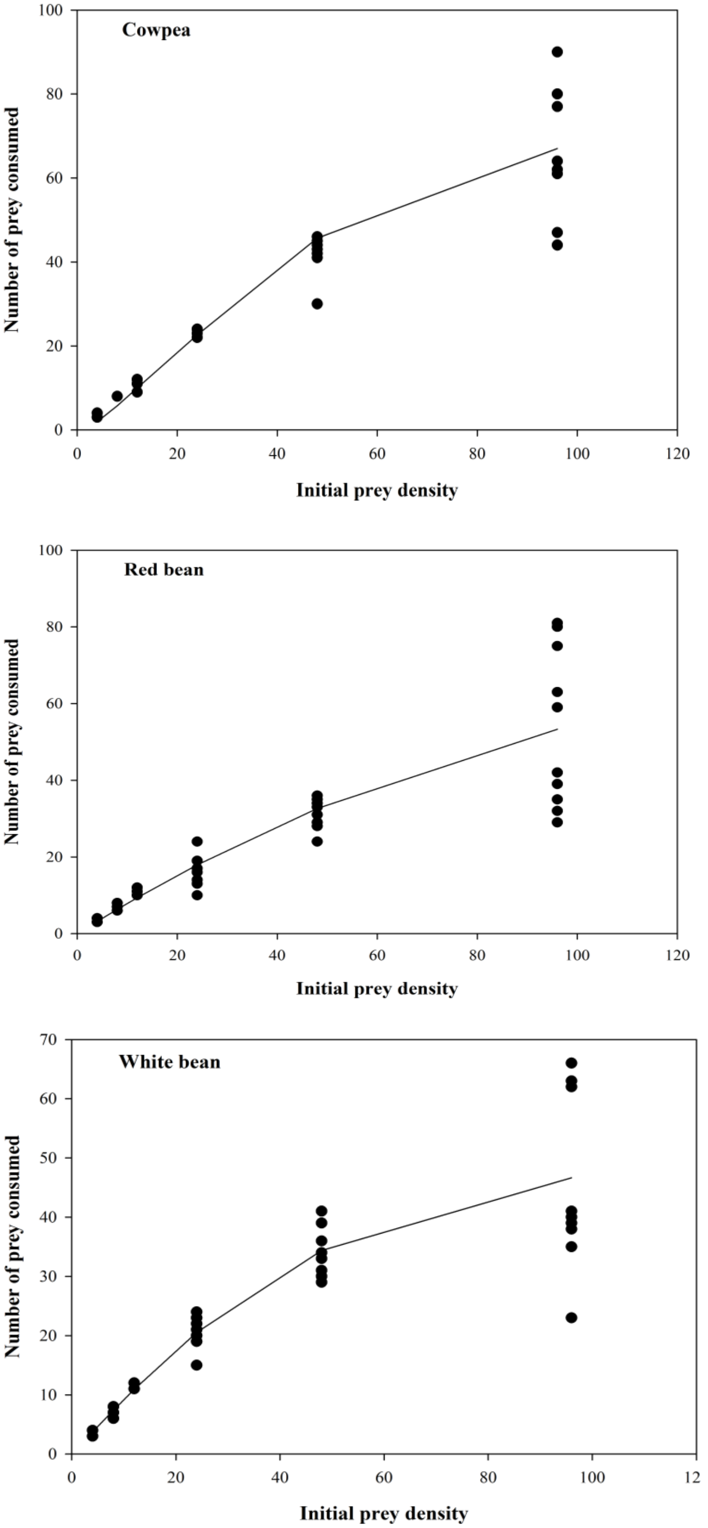

Figure 1. Functional response of *Stethorus gilvifrons* to different densities of *Tetranychus turkestani* on cowpea, white bean and red bean. Symbols are observed data and lines were predicted by model.

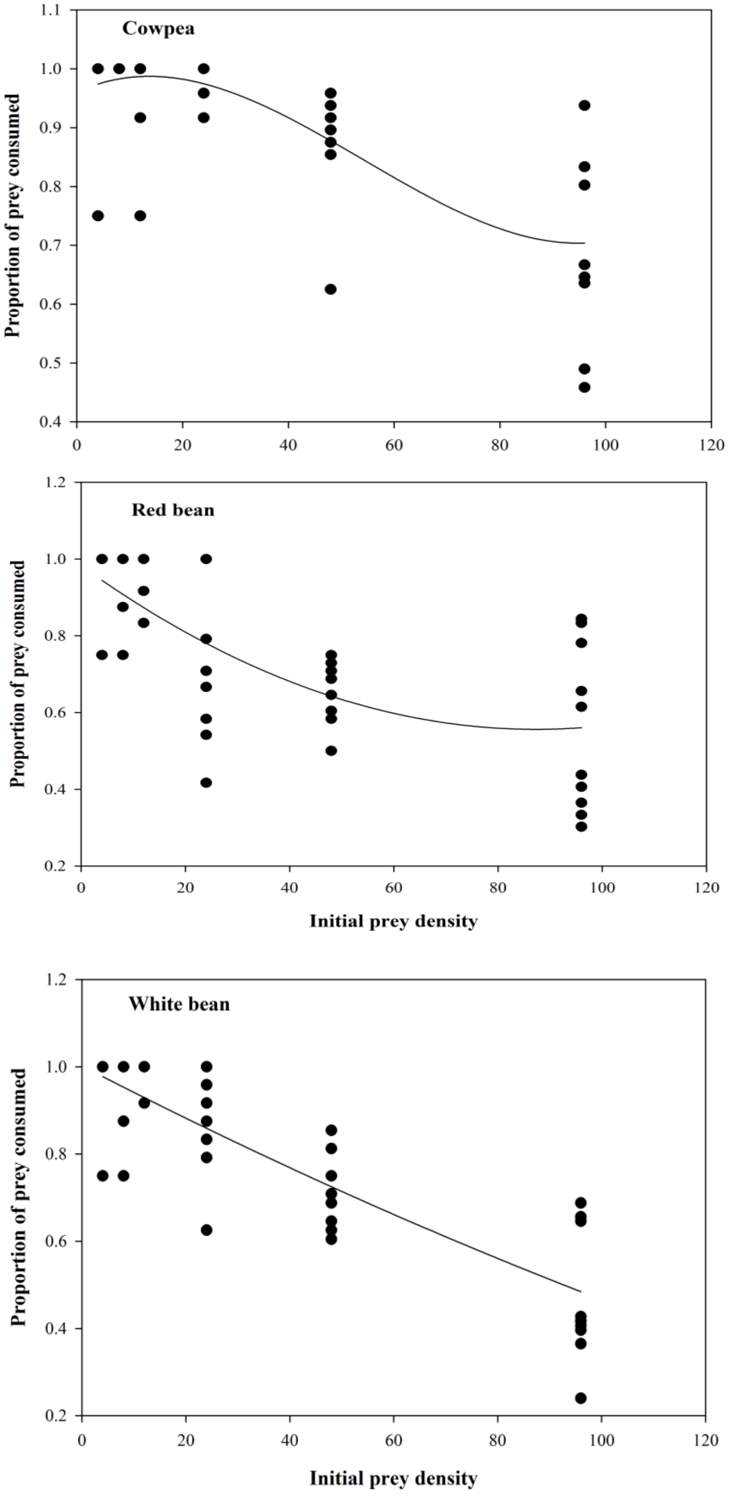

Figure 2: Proportion of *Tetranychus turkestani* consumed by *Stethorus gilvifrons* in relation to prey density on cowpea, white bean and red bean. Symbols are observed data and lines were predicted by model.

Table 2. Parameters (Mean±SE) for linear coefficient of the logistic model fit to proportion of prey density by adult female of *Stethorus gilvifrons* on different plants.

Host plant	Coefficient	Estimate	SE	χ2	*P*
Cowpea	Intercept	3.0055	1.0378	8.39	0.0038
	Linear	0.1450	0.1095	1.75	0.1854
	Quadratic	–0.00521	0.0027	3.66	0.0559
	Cubic	0.000036	0.00002	4.19	0.0406
White bean	Intercept	3.8196	0.7536	25.69	<0.0001
	Linear	–0.0873	0.0670	1.70	0.1925
	Quadratic	0.00057	0.0016	0.13	0.7161
	Cubic	–8.45E–7	9.943E–6	0.01	0.9323
Red bean	Intercept	4.1260	0.5984	47.54	<0.0001
	Linear	–0.2207	0.0523	17.82	<0.0001
	Quadratic	0.00434	0.00122	12.64	0.0004
	Cubic	–0.00003	7.735E –6	11.01	0.0009

Table 3. Parameters (Mean±SE) estimated by Rogers model, evaluating functional response of *Stethorus gilvifrons* adult females to densities of *Tetranychus turkestani* adults on different plants.

Plant	Type	a (Type II) or b (Type III) (h^{-1})	T_h(h)	T/T_h	R^2
Cowpea	III	0.00718±0.00214	0.3299±0.0158	72.74	0.9601
White bean	II	0.1219±0.0301	0.3972±0.0428	60.42	0.944
Red bean	II	0.0691±0.0176	0.2301±0.0688	104.30	0.904

Table 4. Significant differences between functional response of *Stethorus gilvifrons* adult female fed on adult female *Tetranychus turkestani* on white bean and red bean.

Parameter	Estimation	Asymptotic SE	Asymptotic 95% CI	
			Upper	Lower
D_a^*	0.0528	0.0392	0.1305	–0.0248
D_{Th}^{**}	0.1671	0.0791	0.3238	0.0105

* Indicating differences between treatments for *a*.

**Indicating differences between treatments for T_h.

The species of the host plant altered the functional response of *S. gilvifrons* with regard to the magnitude of predation of adult female *T. turkestani*, with the ladybird being more effective on cowpea than on white bean and red bean. The effect of host plants on the functional response of predatory insects has been documented in the literature. Coll and Ridgway (1995) found that *Orius insidiosus* Say had a lower predation rate on *Frankeliniella occidentalis* (Pergande) on tomato plants than on bean and maize plants. They suggested that the presence of glandular trichomes on the surface of tomato leaves might hamper predator searching efficiency and also provide more refuges to protect the thrips against predator attacks. In another experiment, De Clercq et al. (2000) reported that *Podius nigrispinus* (Say) had a lower feeding rate on beet armyworm, *Spodoptera exigua* (Hubner), on tomato than on sweet pepper and eggplant. They proposed that the glandular trichomes on the plant surface and allelochemicals interference with the performance of the predator on the tomato resulted in impaired searching efficiency and predation ability. Karami Jamour and Shishehbor (2012) also reported that lower predation efficiency of *S. gilvifrons* on adult females of *T. turkestani* on cucumber than on cowpea and castor bean leaves might be the result of, among other reasons, the dense trichomes covering the lower surface of cucumber leaves, which might decrease the movement of the predator and increase the prey handling time. Furthermore, the negative effect of leaf hairs and trichomes on the searching ability of predators and parasitoids has been reported by other researchers (Price et al., 1980; van Haren et al., 1987; Walter and O’Dowd 1992; Sütterlin and van Lenteren, 1997; Ricci and Capelletti, 1998; Croft et al., 1999), either as a mechanical mechanism slowing down the movements of the natural enemy (Price *et al*., 1980; Sütterlin and van Lenteren, 1997) or as adhesive secretions, which make the natural enemy spend a large amount of its time cleaning itself (van Haren *et al*., 1987).

The results obtained in the current study indicated that not only the host plant and prey density significantly affected the functional response of *S. gilvifrons* against adult females of *T. turkestani*, but also there is a significant interaction between the host plant species and prey density on the functional response of *S. gilvifrons* preying on *T. turkestani*. In this manner, the influence of the host plant becomes more obvious at high prey densities. A similar trend has been reported for *S. gilvifrons* fed on protonymphs and deutonymphs of *T. turkestani* on three different host plant species (Karami Jamour and Shishehbor, 2012) and for the phytoseiid mite *Phytoseiulus persimilis* Athias-Henriot fed on *Tetranychus urticae* Koch eggs on three different plant species (Skirvin and Fenlon, 2001).

Prevez and Omkar (2005) stated that the handling time and attack rate are two parameters used to ascertain the magnitude of functional response. The handling time is a good index of the consumption rate and predator effectiveness because it determines the accumulative time spent on identifying, chasing, capturing, killing, and eating the prey (Holling, 1959, 1965, 1966). Handling time may be influenced by different factors like the speed of the predator, prey movement, and the time spent overcoming individual prey (Hassell, 1978), which may be related to behavioral and physical mechanisms of prey defense (Ali et al., 2011). In the current study, the handling time recorded for *T. tukestani* adult females on white beans was higher than that on red beans. The differences in handling times of *S. gilvifrons* in this study could be related to the differences observed in the density of leaf trichomes on the tested host plants. Leaf density was higher on white beans than that on red beans. Dense trichomes on white bean leaves can reduce the mobility of *Stethorus punctillum* (Weise) adults foraging for *Tetranychus urticae* Koch eggs but cannot affect the movement of mobile stages of *T. urticae* in the laboratory (Riddick and Wu, 2011). Host plant trichomes can reduce the predation potential of predators (Price et al., 1980; Walter and O'Dowd, 1992; Ricci and Cappelletti, 1998; Riddick and Simmons, 2014).

O’Neil (1989), Wiedenmann and O’Neil (1991), and Messina and Hanks (1998) criticized the functional response studies in small laboratories. They argued that under the field conditions, the factors such as large searching areas, host plants, multispecies prey and/or predator systems, and weather conditions could influence the effectiveness of natural enemies. In the present study, for instance, the experiments were conducted in arenas, where no or very little spider mite webbing was produced. In the bean fields, all *T. turkestani* stages are surrounded by webbing, which may limit the predation efficiency of *S. gilvifrons*. Thus, additional studies evaluating the effect of *S. gilvifrons* on *T. turkestani* in field trials are recommended.

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اثر گیاهان میزبان بر واکنش تابعی کفشدوزک کنه خوار *Stethorus gilvifrons* روی کنه *Tetranychus turkestani*

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چکیده

کنه تارتن توت فرنگی *Tetranychus turkestani* Ugarov and Nikolski یکی از مهم‌ترین آفات گیاهان زراعی و گلخانه‌ای در خوزستان است. هدف این مطالعه بررسی واکنش تابعی کفشدوزک *Stethorus gilvifrons* Mulsant روی تراکم‌های مختلف کنه *T. turkestani* روی سه نوع لوبیا: لوبیا چشم بلبلی (*Vigna unguiculata* L.)، لوبیا سفید (*Phaseolus lunatus* L.) و لوبیا قرمز (*Phaseolus calcaratus* Roxb.) در دمای۲ ± ۳۰ درجه سلسیوس، رطوبت نسبی۱۰ ± ۶۰ درصد و دوره روشنایی: تاریکی ۸:۱٦ ساعت بود. هر کفشدوزک بالغ به مدت ٢٤ ساعت بر روی برگ‌های هر کدام از میزبان‌های گیاهی مذکور حامل تراکم‌هایی از ٤، ٨، ١٢، ٢٤، ٤٨ و ٩٦ کنه بالغ *T. turkestani* روی دیسک برگی در یک پتری دیش با قطر ۹ سانتی‌متر نگهداری شد. تجزیه و تحلیل رگرسیونی لوجستیک نشان داد نوع واکنش تابعی روی لوبیا چشم بلبلی، لوبیا سفید و لوبیا قرمز به ترتیب نوع سوم ، دوم و دوم بود. بیش‌ترین نرخ حمله (۰/۱۲۱۹) و کوتاه‌ترین زما ن دست‌یابی (۰/۲۳۰۱) به ترتیب روی لوبیا سفید و لوبیا قرمز ثبت شد. بیش‌ترین نرخ شکارگری (T/T_h) روی گیاهان مذکور ۷۲/۷٤، ٦۰/٤۲ و ۱۰٤/۳۰ کنه در روز بود. این مطالعه آزمایشگاهی پیشنهاد می‌کند که خصوصیات گیاه میزبان بر توانایی کفشدوزک *S. gilvifrons* جهت واکنش به تغییر در تراکم کنه *T. turkestani* اثر می‌گذارد.

کلیدواژه‌ها: نرخ حمله، زمان دست‌یابی، بقولات، کنه تارتن توت فرنگی