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Effects of Prey Species and Host Plants on Development and Life History of *Stethorus gilvifrons* (Coleoptera: Coccinellidae)

M. Jafari[1], H. Ranjbar Aghdam[2*], S. Goldasteh[1], A. Zamani[3], and E. Soleiman Nejadian[1]

ABSTRACT

Stethorus gilvifrons **(Mulstant) is an important voracious predator of the spider mites, which consumes all the life stages of spider mites. In this study, the effects of prey species and host plants on development and life table parameters of *S. gilvifrons* were studied. To this end, preimaginal development, survival, adult longevity and fecundity of *S. gilvifrons* fed on *Tetranychus urticae* Koch (on maize and cowpea) and *Eutetranychus orientalis* Klein (on castor bean plants) were studied. Experiments were conducted based on two-sex life table procedure under laboratory conditions at 27±1°C, 60–70% RH and 16:8 hours L:D. The shortest developmental time and female longevity were recorded on maize and cowpea, respectively, and the longest was on castor bean. While the lowest values of fecundity, net Reproductive rate (R_0) and intrinsic rate of increase (r) were estimated at 107.65±11.49 offspring, 20.63±4.41 offspring and 0.1001±0.0072 d^{-1} on castor bean, respectively, the highest values of the mentioned parameters were 158.67±20.18 offspring, 43.63±8.47 offspring, and 0.1448 ± 0.0069 d^{-1} on maize, respectively. The results proved the significant effects of the host plants and prey species on developmental time and demographic parameters of *S. gilvifrons*. The obtained results could be useful for mass rearing of *S. gilvifrons* and for better understanding of its population dynamics in relation to the prey species and host plants.**

Keywords: Biological control, Life table, Predatory Coccinellid, Rearing, Spider mites.

INTRODUCTION

The two spotted spider mite, *Tetranychus urticae* Koch (Acari: Tetranychidae) is one of the most economically important pests in greenhouses and field crops worldwide (Helle and Sabelis, 1985; Bolland *et al.,* 1998). The citrus brown mite, *Eutetranychus orientali s* (Klein) (Acari: Tetranychidae), is also an important polyphagous pest, mainly found in association with citrus crops in the tropical regions in the Middle East, Africa, Southern and Eastern Asia and Australia (Jeppson *et al*., 1975; Chazeau, 1985). They cause significant damage on horticultural plants in both fields and greenhouses. Unfortunately, control of the spider mites is difficult and using acaricides is the commonly used method to control the pest. While they have high developmental rate, short life span, and high reproductive potential, their ability to develop resistance to many acaricides, has made the chemical control of this mite particularly difficult (Luczynski *et al*., 1990; Van Leeuwen *et al*., 2008; Van Leeuwen *et al*., 2010). Therefore, there are many problems associated with the

[1] Department of Entomology, College of Agriculture, Arak Branch, Islamic Azad University, Arak, Islamic Republic of Iran.
[2] Iranian Research Institute of Plant Protection, Agricultural Research, Education and Extension Organization, Tehran, Islamic Republic of Iran.
[3] Department of Plant Protection, College of Agriculture, Razi University, Kermanshah, Islamic Republic of Iran.
* Corresponding author; e-mail: hrap1388@gmail.com

use of pesticides, including secondary pests' outbreak and resistance development, pesticides impact on the environment, high costs and human safety; therefore, researchers look for alternative methods of managing the spider mites (Helle and Sabelis, 1985; Van Leeuwen *et al*., 2007; Attia *et al*., 2013).

Stethorus gilvifrons (Mulstant) (Coleoptera: Coccinellidae), is an important voracious predator of the spider mites on various crops, which consumes all of the life stages of the spider mites, in particular, the female needs abundant prey supplies before oviposition period (McMurtry and Johnson, 1966; McMurtry *et al*., 1970; Hull *et al*., 1977; Helle and Sabelis, 1985). This species is capable of effective dispersal and is currently produced for augmentative biological control (McMurtry and Johnson, 1966; Riddick and Wu, 2011).

Plants, herbivores and natural enemies are tightly entwined (Awmack and Laether, 2002). Tritrophic interactions may include direct effects of host plants on herbivores and direct or indirect effects of host plants on the natural enemies of herbivores (Price *et al*., 1980; Gassmann *et al.* 2010). Host plants may reduce the fitness of herbivores through the presence of toxic allelochemicals or physical defenses (Rosenthal and Berenbaum, 1991). These interactions may be mediated by either the nutritional, defensive, or physical qualities of the host plants (Vet and Dicke, 1992; Awmack and Laether, 2002; Dick *et al*., 2009). For instance, variation in host plant quality may affect the body size, egg size and quality, the performance of male insects, delaying herbivore establishment, and thus an increased chance of exposure to natural enemies and herbivore sex ratios of herbivorous insects, which, in turn, can determine life history parameters such as fecundity, fertility, longevity and survival, all directly relevant to population dynamics (Awmack and Laether, 2002; Karimzadeh *et al*., 2004; Karimzadeh and Wright, 2008; Reynolds *et al*., 2009, Karimzadeh *et al*., 2013). However, harmful effects of host plants may be offset by benefits if the plant defenses are detrimental to the natural enemies of herbivores and increase survival of herbivores when challenged with natural enemies (Price *et al*. 1980, Jeffries and Lawton 1984).

Although previous studies on *Stethorus* spp. were mostly focused on biological characteristics (Putman, 1955; Biddinger, 2009; Fiaboe *et al*., 2007), functional response (Osman and Bayoumy, 2011; Karami Jamour and Shishehbor, 2012; Bayoumy *et al*., 2014), life table (Rattanatip *et al*., 2008; Imani *et al*., 2009; Perumalsamy *et al*., 2010 ; Handoko and Affandi, 2012), and the effect of temperature (Rott and Ponsonby, 2000; Roy *et al*., 2002; Taghizadeh *et al*., 2008a, b; Matter *et al*., 2011; Khan and Spooner-Hart, 2017); the effect of host plants and prey species on development and demographic parameters of *S. gilvifrons* has not been studied yet. Therefore, the present study was conducted to examine the effect of spider mites species reared on different host plants on life history of *S. gilvifrons*.

MATERIALS AND METHODS

Plant Materials and Preys

Tested host plants were maize, *Zea mays* (Var. KSC 704), cowpea, *Vigna catjang* Endi (Var. Khomein) and green bean, *Phaseolus vulgaris cv.* (Var. Sunray) as natural hosts for mass rearing of *T. urticae;* and castor bean, *Ricinus communis* L. was applied as host for the citrus brown mite, *E. orientalis*. Maize and castor bean seeds were planted in plastic pots with 24 cm diameter and 26 cm height, and cowpea and green bean were planted in plastic pots with 18 cm diameter and 20 cm height. All the pots were filled with a mixture of sandy loam, loam and compost in equal proportions. No pesticides were used during the growing period of the plants. All of the pots were planted in separate greenhouse at 27±5˚C temperature, 50±10% RH and natural photoperiod, during growing season. Maize, cowpea, green bean and castor bean were continuously planted every two weeks in the greenhouse. About 4 weeks after germination, when all the plants had grown enough in the greenhouse, each plant was infested by one of the spider mite species. Two-spotted spider mites were originally collected from bean fields of Varamin Region located in Tehran Province, Iran, and citrus brown mites were collected from castor beans planted in campus of Shahid Chamran University, Ahvaz, Iran. Two-spotted spider mite, *T. urticae* was used for infestation of maize, cowpea and green bean plants, and citrus brown mite, *E. orientalis*, was used for infestation of castor bean.

In order to provide sufficient density of the mites for rearing of the predatory coccinellid, the mites were reared for several generations on the host plants in the greenhouse.

Predator Colony Establishment

Adults of *S. gilvifrons* (≈ 300 cocclinellids) were collected from the sugarcane fields, located in Ahvaz District, Khuzestan Province, southwest of Iran (48º 40′ E, 31º 20′ N) using an aspirator, and transferred in a Plexiglas jar (5×14×19 cm) containing sugarcane leaves infested by *Oligonychus sacchari* (McGregor) (Acari: Tetranychidae). Collected adults were randomly divided into three equal groups. Each group had about 100 individuals, and were reared separately on the determined hosts in growth chamber at 27±1˚C temperature, 50±10% RH and a photoperiod of 16:8 (L:D) hour. The second laboratory generation (F_2) of *S. gilvifrons* was used for the current study. Rearing of the predatory coccinellid was carried out in insectarium at 27±1°C, 60–70% RH, and 16:8 hours (L:D), inside cage. Rearing cages were 70×70×120 cm in dimensions and covered by fine metal nets to prevent the coccinellids from exit. Within each rearing cage, 2-4 pots were placed, depending on the size of the plants. In each cage, 20 individuals (10 males and 10 females) of *S. gilvifrons* were released from wild population. Each cage was checked weekly and, if needed, its pots were replaced with new infested pots. Irrigation of the pots was done every week.

Life Table Study

We could not establish the colony of *S. gilvifrons* on green bean (*Phaseolus vulgaris cv.*) and all of larvae died before completing their development. Thus, life table studies were done by using three treatments; first treatment was feeding of *S. gilivfrons* by *T. urticae* reared on maize, second treatment was feeding *S. gilivfrons* by *T. urticae* reared on cowpea, and third treatment was feeding of the predatory coccilelid by *E. orientalis*, reared on castor bean plants. Then, 120 eggs with less than 24 hours-old were selected as a cohort for each treatment. For this purpose, three fold 10 pairs of *S. gilivfrons* were isolated for 24 hours in three plastic containers (19×14×4 cm), separately on maize, cowpea, and castor bean leaf discs (6-10 cm diameter) that were infested by *T. urticae* and *E. orientalis*, respectively. Then, the laid eggs were collected and individually transferred on leaf discs of the tested plants. After hatching the eggs, each larva was located in an individual rearing plastic container (8 cm in diameter and 3 cm height). Depending on the treatment, larval feeding was carried out by providing about 300 individuals of *T. urticae* or *E. orientalis* for each larval rearing container daily. Life table studies were carried out in growth chamber at 27±1°C temperature, 60–70% RH and a photoperiod of 16:8 hours (L:D). Then, developmental time and mortality of the immature stages were recorded at daily intervals. Different larval instars of the predator were determined according to their size and observing larval exuviae in the containers. Based on the data, incubation, larval and pupal periods were determined for the individuals.

Newly emerged adults were paired in plastic containers with the dimension of 19×14×4 cm for mating and oviposition. Survival and oviposition of the coccinellids were recorded daily until death of all the individuals. By the beginning of the reproduction, females and males were transferred daily to new containers with freshly infested leaf discs by the spider mites. Moreover, longevity and fecundity of the adults were recorded. The obtained eggs were kept separately until hatching to estimate hatch rate. The number of hatched eggs were used to estimate female fecundity. A fine brush (no. 0.000) was used to transfer mites and different stages of predators on the leaf discs in petri dishes.

Life Table Data Analysis

The raw data of *S. gilvifrons* individuals were analyzed by using the Two sex-MSChart computer program (Chi, 2017), according to the age-stage two-sex life table theory (Chi and Liu, 1985) and the method described by (Chi, 1988).

The bootstrap technique (Efron and Tibshirani, 1993; Yu *et al*., 2013) was used to estimate the variances, and standard errors of the population parameters. Because bootstrapping uses random sampling, a small number of replications will generate variable means and standard errors. To generate less variable results, we used 100,000 replications in this study. The paired bootstrap test based on confidence interval (Efron and Tibshirani, 1993; Akca *et al*., 2015; Reddy and Chi, 2015) was used to compare the difference in developmental time, adult longevity, Adult Preoviposition Period (APOP), Total Preoviposition Period (TPOP), oviposition period, and fecundity among treatments. The population parameters, including intrinsic rate of increase (r), finite rate of increase (λ), net Reproductive rate (R_0), and mean generation Time (T) among treatments were also compared by using the paired bootstrap test (Reddy and Chi, 2015). The graphs were drawn using SigmaPlot 12 software.

RESULTS

Developmental Time

Out of 120 same-aged eggs, 118 eggs successfully hatched on maize leaf discs infested by *T. urticae*, and 79 larvae developed to pupal stage. Among pupae, 62 individual developed to adult stage. On cowpea leaves infested by *T. urticae*, however, all of the eggs (n= 120) hatched into larvae, completely developed larvae and pupae were, 45 and 41 individuals, respectively. In addition, 53 eggs hatched on castor bean leaves infested by *E. orientalis* and 34 larvae, pupae and adult developed successfully to this stage. No significant differences were detected in the duration of pupal period among *S. gilvifrons* on three examined host species (Table 1). Mean total development times of *S. gilvifrons* female on infested cowpea was (12.39±0.29 days) shorter than those on infected maize and castor bean (Table 1).

Fecundity

Females began oviposition at the 11^{th}, 12^{th} and 15^{th} days on cowpea, maize, and castor bean, respectively (Figure 4). The effect of the infected host plants on the development of *S. gilvifrons* was also be observed in the Adult Preoviposition Period (APOP) and the Total Preoviposition Period (TPOP). The shortest APOP (1.789 days) and TPOP (14.37 days) were observed on cowpea, while the longest APOP (5.09 days) and TPOP (18.87 days) were found on castor bean. The mean fecundity of *S. gilvifrons* reared on maize (158.67 eggs) was considerably higher than that of individuals that developed on castor bean (107.65 eggs). However, there was no significant difference between cowpea and the other two host plants (Table 2).

Life Table and Population Parameters

According to the age-stage survival curve (Figure 1), development of *S. gilvifrons* on

Table 1. Mean (±SE) developmental time of different immature stages of *Stethorus gilvifrons* on maize, cowpea, and castor bean.[a]

Gender	Immature Stage	Preys and host plants					
		n	*T. urticae* on maize	n	*T. urticae* on cowpea	n	*E. orientalis* on castor bean
Female	Incubation period	118	3.27± 0.10a	120	3.52 ± 0.14a	53	4.26 ± 0.09b
	Larval stage	79	7.21 ± 0.18a	45	6.00 ± 0.21b	34	6.61 ± 0.24b
	Pupal stage	62	2.82 ± 0.07a	41	2.87 ± 0.10a	34	2.91 ± 0.09a
	Immature stage	33	13.30 ± 0.02a	33	12.39 ± 0.29b	23	13.78 ± 0.26a
Male	Incubation period	118	3.55 ± 0.15a	120	3.56 ± 0.15a	53	4.36 ± 0.20b
	Larval stage	79	7.03 ± 0.21a	45	6.17 ± 0.20b	34	6.27 ± 0.30b
	Pupal stage	62	2.90 ± 0.08a	41	3.06 ± 0.06a	34	3.09 ± 0.09a
	Immature stage	29	13.48 ± 0.24a	18	12.78 ± 0.22b	11	13.73 ± 0.47ab

[a] *SEs* were estimated by using 100000 bootstraps. Followed means by different letters within rows are significantly different, using paired bootstrap test at P= 5%.

Table 2. Adult longevity, Adult Preoviposition Period (APOP), Total Preoviposition Period (TPOP), oviposition period and fecundity of *Stethorus gilvifrons* on maize, cowpea, and castor bean.[a]

Biological parameters	Preys and host plants					
	T.urticae on maize		*T.urticae* on cowpea		*E. orientalis* on castor bean	
	n	Mean ± SE	n	Mean ± SE	n	Mean ± SE
Female life span (Day)	33	37.06 ±1.81a	23	37.26±4.28a	23	47.91±2.35b
Male life span (Day)	29	22.14±1.48 a	18	41.39±3.45b	11	31.91±3.29c
APOP (Day)	33	2.55±0.123 a	19	1.789±0. 3202b	23	5.09±0.2661c
TPOP (Day)	33	15.58±0.2348a	19	14.37±0.3648b	23	18.87± 0.384c
Oviposition period (Day)	33	18.15±1.71a	19	21.42±4.05a	23	23.09±1.90a
Fecundity (Eggs)	33	158.67±20.18a	23	151±36.30ab	23	107.65±11.49b

[a] *SEs* were estimated by using 100000 bootstraps. Followed means by different letters within rows are significantly different, using paired bootstrap test at P= 5%.

maize was faster than the other host plants. The highest value for the age-stage survival rate of the male and female predator were obtained on maize as 0.2166 and 0.2666 at 15th and 16th days, respectively. In contrast, this parameter for the *S. gilvifrons* male and female on cowpea were 0.1416 and 0.1916 at 14th and 15th days, and 0.05 and 0.1916 at 13th and 18th days on castor bean respectively.

The number of offsprings produced by an individual of *S. gilvifrons* in age *x* and stage *j* is shown in Figure 2. Moreover, age-specific survival rate (l_x), age-specific fecundity (m_x), and age-specific maternity ($l_x m_x$) show periodic peaks in reproduction (Figure 2). Based on the estimated data for these curves, the highest values for m_x and f_x were 9.45 and 11.55 eggs per female on maize. In contrast, the lowest value of age-specific maternity for m_x and f_x were 5.03 and 6.63 eggs per female on castor bean, respectively (Figure 2).

The values of age-stage life expectancy of *S. gilvifrons* female at the age zero on maize, cowpea and castor bean were 25.99, 27.26 and 35.91 days, respectively (Figure 3).

Based on the results, the reproductive value of predator was affected considerably by hosts, and the highest reproductive value was 63.94 obtained on cowpea in 26th day. On maize, an increase in reproductive value occurred at age 20th day with the value of 53.80. The highest reproductive values on castor bean were 48.74 in 24th day (Figure 4). The net Reproductive rate (R_0) varied from the highest 43.63±8.47 on maize to the lowest

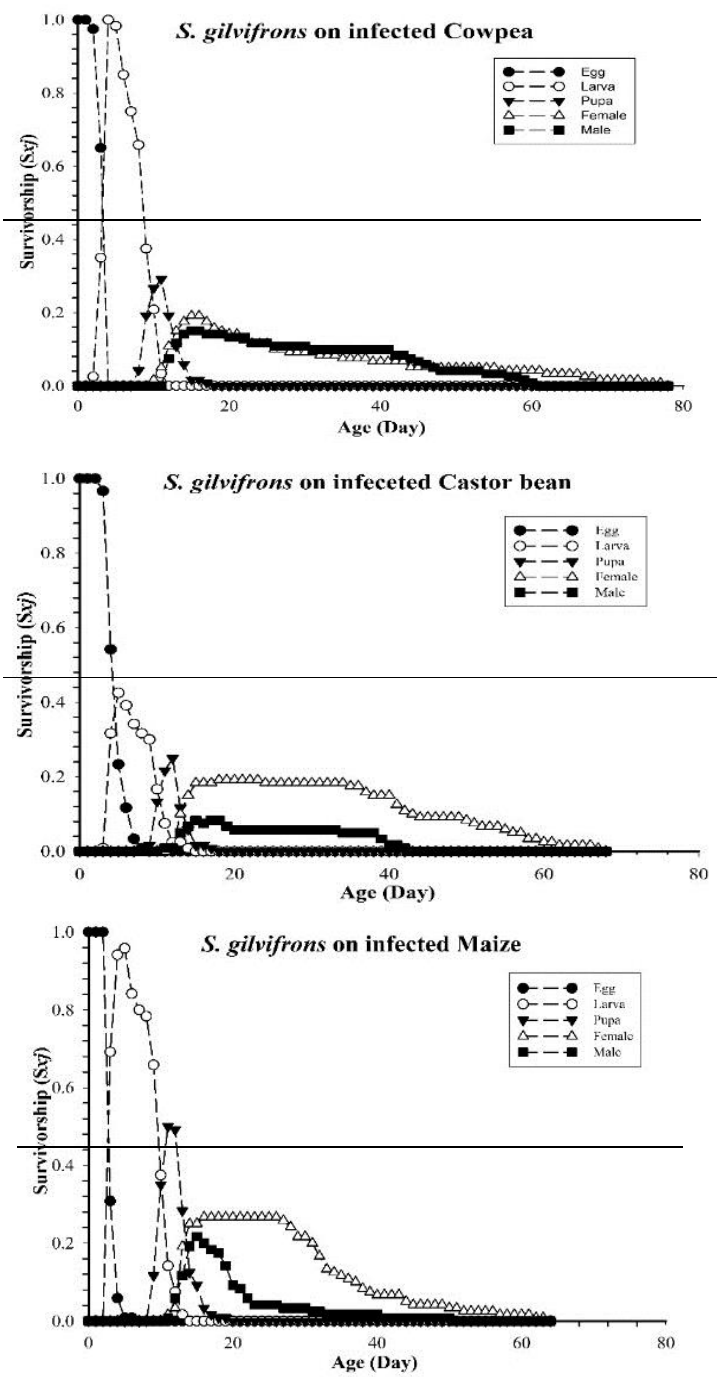

Figure 1. Age-stage specific survival rate of *S. gilvifrons* reared on three infected host plants.

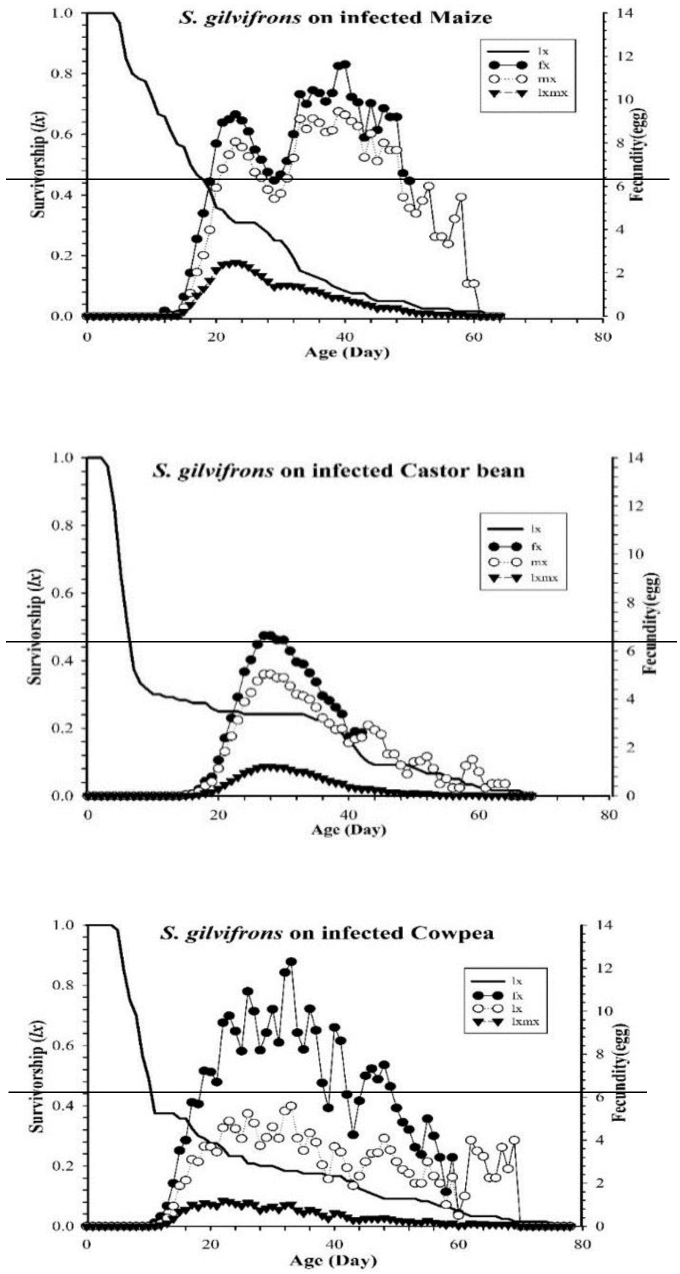

Figure 2. Age-specific survivorship (l_x), age-stage fecundity (f_x) of the female stage, age-specific fecundity m_x, and age-specific maternity (l_xm_x) o of *S. gilvifrons* reared on three infected host plant.

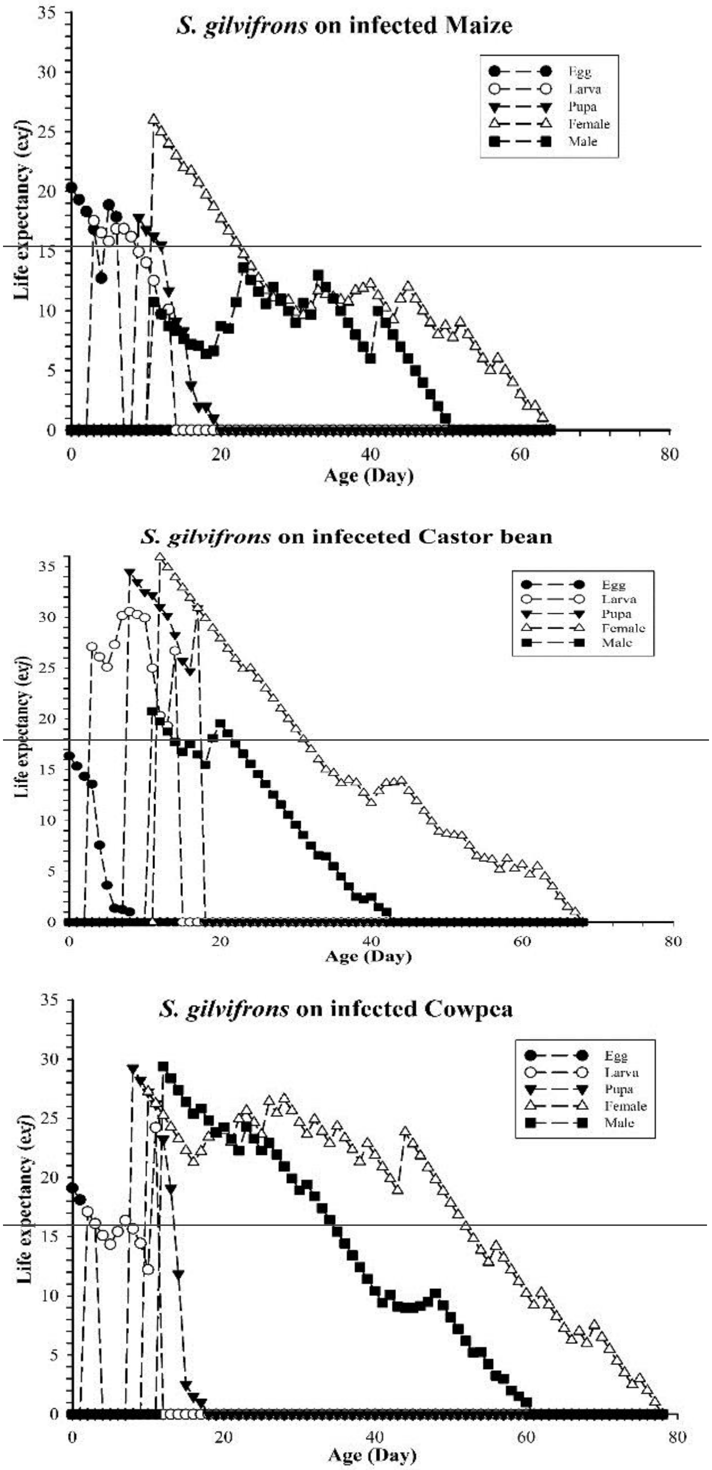

Figure 3. Age-stage specific life expectancy of *S. gilvifrons* reared on three infected host plants.

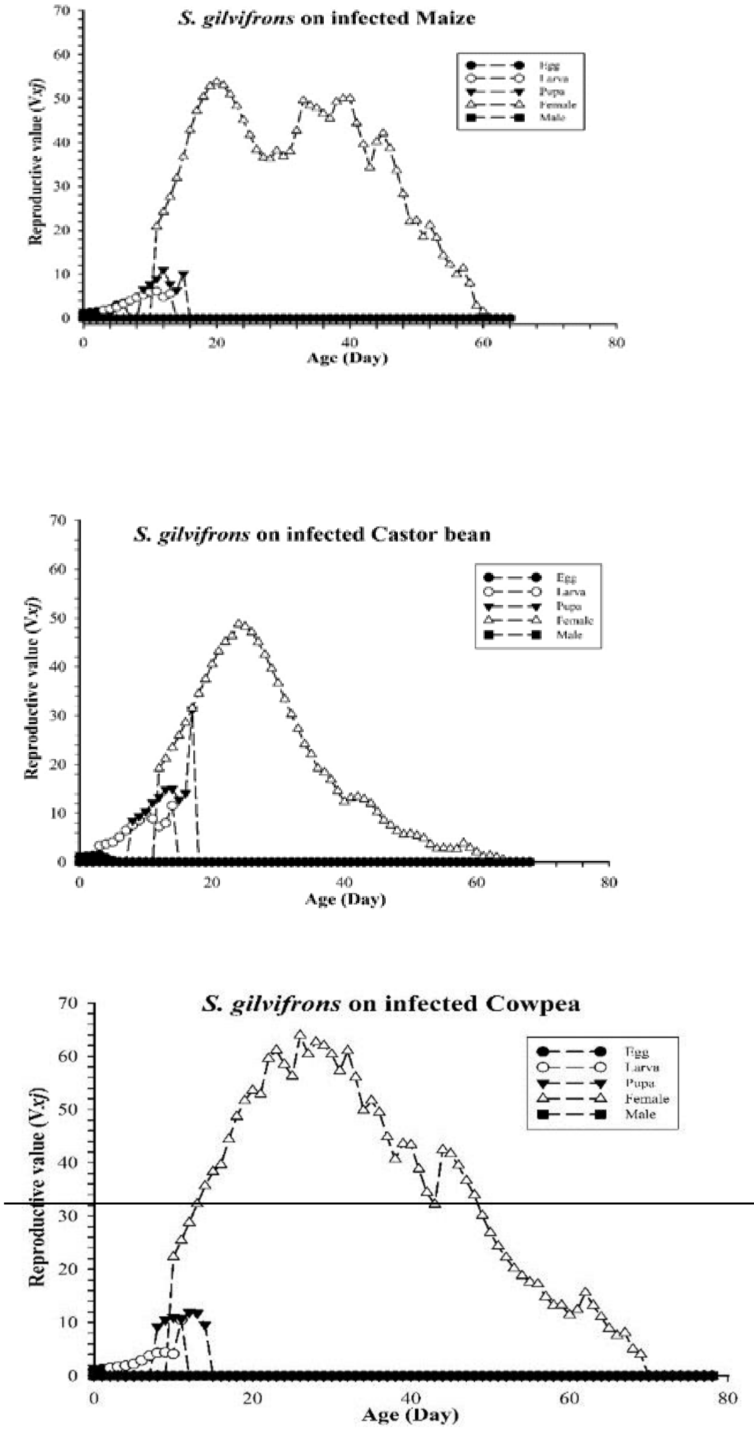

Figure 4. Age-stage specific reproductive value (v_{ij}) of *S. gilvifrons* reared on three infected host plants.

20.63±4.41 offspring/individual on castor bean.

According to the paired bootstrap test, there was a significant difference among some values of the mentioned parameters of *S. gilvifrons* on maize, cowpea, and castor bean. However, maize and cowpea were more suitable hosts than castor bean for development and population increase of *S. gilvifrons*, considering all of the mentioned parameters (Table 3). The highest intrinsic rate of increase (r= 0.1448 d^{-1} and finite rate (λ= 1.15 d^{-1}) were observed on maize, while the lowest r (0.1001 d^{-1}) and λ (1.105 d^{-1}) were observed on castor bean. The shortest mean generation Time (T) was 26.06 d and 25.88 on maize and cowpea and this was significantly shorter than that of the castor bean (Table 3).

DISCUSSION

Plants provide the primary interface between insect herbivores and their natural enemies (Price, 1997). Effects of host plant on the foraging and predation behavior of predators as biological control have been well studied (Evans, 1976; Messina and Hanks, 1998; Rott and Ponsonby, 2000; Stavrinides and Skirvin, 2003; Madadi *et al*., 2009; Kasap 2011; Karami Jamour and Shishehbor, 2012; Bayoumy *et al*., 2014). Plant, pest, natural enemy and environment are four components of an interactive system in biological control that should be understood to design a successful Integrated Pest Management (IPM) program (Duffey *et al*., 1986). To study more on these facts, we focused here on the ways in which components of the host plants of herbivory insects indirectly affect natural enemy development and their demographic parameters. As expected, significant differences between life history of *S. gilvifrons* feeding on *T. urticae* or *E. orientalis* on different host plants were observed. The results of this study illustrate that the development time of *S. gilvifrons* female, in immature stages, was approximately 13.00 days on both spider mites (Table 1), which is close to the findings of Roy *et al*. (2002) on the *T. mcdanieli* as prey for *S. punctillum* on red raspberry, *Rubus idaeus* L.. However, longer developmental time (17.54 days) was reported by Taghizadeh *et al.* (2008b) for *S. gilvifrons* preying on two-spotted spider mite and *T. urticae*, on bean leaves (*Phaseolous vulgaris* L.). Moreover, according to Fiaboe *et al*. (2007), developmental time of *S. tridens* Gordon was reported 16.20 days feeding on *T. evansi* on the leaves of *Solanum americanum* Mill. Similarly, developmental time of *S. pauperculus* (Weise) feeding on *T. urticae* on the leaves of mulberry was more than those found in the current study (14.05 days) (Rattanatip *et al*., 2008). On the other hand, shorter developmental time for *Stethorus* spp. was reported by many researchers. e.g. 12.00 days was reported for

Table 3. Life table parameters (Mean±SE) of *Stethorus gilvifrons* on maize, cowpea, and castor bean plants by spider mites.[a]

Life table parameters	Preys and host plants		
	Tetranychus urticae on maize	*T. urticae* on cowpea	*Eotetranychus orientalis* on castor bean
Gross reproductive rate (*GRR*) (Offspring)	283.43 ± 43.97a	180.76 ± 42.95ab	108.81± 15.54b
Net reproductive rate (*R*0) (Offspring)	43.63 ± 8.47a	28.94 ± 8.71ab	20.63 ± 4.41b
Intrinsic rate of increase (*r*) (d^{-1})	0.1448± 0.0069 a	0.1300 ± 0.011a	0.1001 ± 0.0072b
Finite rate of increase (λ) (d^{-1})	1.15 ± 0.0080a	1.138 ± 0.0135a	1.105 ± 0.0081b
Mean generation Time (*T*) (Day)	26.06 ± 0.95a	25.877 ± 1.025a	30.236 ± 0.756b

[a] *SEs* were estimated by using 100000 bootstraps. Followed means by different letters within rows are significantly different, using paired bootstrap test at P= 5%.

S. japonicas Kamiya preying on *T. urticae* on lima bean (*Phaseolus lunatus* L.) by Mori *et al*. (2005); 10.00 days was reported for *S. gilvifrons* on castor bean, feeding on *T. turkestani* and *E. orientalis* by Imani *et al*. (2009); and 11.25 days for *S. siphonulus* on mulberry, feeding on *T. urticae* by Rattanatip *et al*. (2008) at the same temperature. Total developmental time of the males was very close to the females feeding on both prey species. Similar trend was reported for *S. japonicas* feeding on *T. urticae* (Mori *et al*., 2005) and *S. gilvifrons* feeding on *T. turkestani* and *E. orientalis* (Imani *et al*., 2009). Differences between these findings and ours may be due to the differences in quantity and quality of nutrients in different host plants, prey and predator species, populations, rearing procedure, and experimental conditions.

The highest egg mortality was observed on the castor bean probably due to the nutritional and defensive compounds of the plant. Vermeer *et al*. (2003) estimated 1.8 μ g cm^{-2} of cuticular waxes from the extracts of the primary leaves of castor bean. Differences in plant chemistry may have subtle influences on life table parameters, either directly through toxic or repellent effects (Vet and Dicke 1992), via defensive compounds induced by herbivore feeding, or via indirect effects on the palatability of the prey (Sabelis *et al*., 1999). Thus, contributions of leaf chemistry on host plant effects cannot be ignored. On the other hand, it seems more likely that the surface structures of castor bean leaves mechanically impeded the movement of *S. gilvifrons* and decreased reaction speed of predator. In our study, *S. gilvifrons* female's life span were 37.06 days and 47.91 days on maize and castor bean, respectively. Similar results were obtained (45.5 day) for *S. gilvifrons* preying on *E. orientalis* by Imani *et al*. (2009) and 35.24 days for *S. siphonulus* preying on *T. urticae* (Rattanatip *et al*., 2008). However according to Fiaboe *et al*. (2007) life span of *S. tridens* was 71.60 days when it fed on *T. evansi*. In addition, Taghizadeh *et al*. (2008a) found that longevity of *S. gilvifrons* was 14.50 days at 27±1°C, preying on *T. urticae*. Oviposition of the predator on examined plants showed the effect of host plants and prey type on total fecundity. Total fecundity of *S. gilvifrons* were 158.67, 151, and 107.65 eggs $female^{-1}$ on maize, cowpea, and castor bean, respectively. Similarly, Imani *et al*. (2009), Taghizadeh *et al*. (2008a), and Fiaboe *et al*. (2007) reported 175.14, 145.20 and 123.00 eggs $female^{-1}$ for *S. gilvifrons* preying on *T. turkestani*, *T. urticae*, and *T. evansi*, respectively. In contrast, Rattanatip *et al*. (2008) reported 348 eggs $female^{-1}$ for *S. pauperculus* preying on *T. urticae* and 414 eggs $female^{-1}$ for *S. siphonulus* preying on *T. urticae*, and Imani *et al*. (2009) reported 318 eggs $female^{-1}$ for *S. gilvifrons* preying on *E. orientalis*. These differences can be attributed to differences in predator, prey and host plant species, population and experimental conditions. Plant quality may affect higher–trophic level interactions either via the diet of the prey (and therefore prey quality) or by the provision of refuge allowing prey to avoid natural enemies (van Emden and Wratten, 1990; Obrycki and Kring, 1998; Bottrell *et al*., 1998; Giles *et al*., 2002).

Many laboratory studies have reported a variety of (*r*) values for *S. gilvifrons*. For example, Fiaboe *et al*. (2007) found this value as 0.104 d^{-1} when *T. evansi* was provided as prey for this predator. According to Imani *et al*. (2009), these values were obtained as 0.171 and 0.221 d^{-1} on *T. turkestani* and *E. orientalis*, respectively. Taghizadeh *et al*. (2008b) found this value as 0.145 d^{-1} on *T. urticae* as prey at 27±1°C. The intrinsic rate of increase (r) for *S. gilvifrons* feeding on *T. urticae* on maize (0.1448 d^{-1}) is similar or higher than those reported for *S. gilvifrons* feeding on different tetranychid species at the same temperature. Differences in the ecological factors, prey species, geographical strains of the predator, and host plant, as well as evaluation methods and analysis may provide an explanation for differences in *r* value in *Stethorus* spp.

In the present study, it was shown that most larval diets had a strong influence not only on preimaginal development but also on female longevity and fecundity. Moreover, it is revealed that the influence of the pests nourishing by host plants on the development and reproductive of predators as biological control agents has been inevitable. For example, developmental and reproductive parameters of *Episyrphus balteatus* De Gecer (Diptera: Syrphidae), were affected by prey and host plant species (Vanhaelen *et al*., 2002). Riddick and Wu (2011) reported that lima bean (*P. lunatus*) hooked trichomes density, had negative effect on survival of *Stethorus punctillum* Weise to control spider mites and Putman (1955) reported larvae of *S. punctillum* were quickly killed by contact with the hooked trichomes on scarlet runner bean, *Phaseolus coccineus* L. leaves. In addition, results of Giles *et al*. (2002) confirmed the interactions among host plants, aphid prey, and preimaginal biology of *Coccinella septempunctata* L. All of the mentioned studies showed that, because predators often encounter herbivores on plants, the topography of plant surfaces may influence herbivore and natural enemies interactions (Dicke, 1996; Roda *et al*., 2001) and also host plant quality is expected to enhance the predators via nourishing of pests (Nachman and Zemek, 2002).

In conclusion, the results obtained here showed that host plant and prey species influence developmental rate, survivorship, and reproduction of *S. gilvifrons*. Moreover, for mass rearing of *S. gilvifrons*, infected maize plants by *T. urticae* can be recommended as a better host in comparison with cowpea infected by the same spider mite or castor bean infected by *E. orientalis*.

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اثرات گونهٔ شکار و گیاهان میزبان روی نمو و جدول زندگی کفشدوزک شکارگر *Stethorus gilvifrons* (Coleoptera: Coccinellidae)

م. جعفری، ح. رنجبراقدم، ش. گلدسته، ع. زمانی و ا. سلیمان‌نژادیان

چکیده

یکی از شکارگران مهم و پرخور کنه‌های تارتن، کفشدوزک *Stethorus gilvifrons* (Mulstant)می‌باشد، که از تمامی مراحل زندگی این کنه تغذیه می‌کند. در این پژوهش، تاثیر گونه‌های شکار و گیاهان میزبان مختلف روی روند رشد و نمو و پراسنجه‌های جدول زندگی کفشدوزک *S. gilvifrons*بررسی شد. برای این منظور، طول دورهٔ رشدی مراحل نابالغ، زنده‌مانی، طول عمر و میزان باروری کفشدوزک‌های بالغ با تغذیه از کنهٔ تارتن دو لکه‌ای، *Tetranychus urticae* Koch روی گیاهان میزبان ذرت و لوبیا چشم بلبلی و کنهٔ شرقی مرکبات، *Eutetranychus orientalis* Klein روی گیاه کرچک، مورد بررسی قرار گرفت. آزمایش‌ها طبق روش تجزیهٔ جدول زندگی دو جنسی در شرایط آزمایشگاهی در دمای ۱±۲۷ درجهٔ سلسیوس، رطوبت نسبی۶۰-۷۰ درصد و دورهٔ نوری ۱۶ ساعت روشنایی و ۸ ساعت تاریکی انجام شد. بر اساس نتایج، کوتاه‌ترین دورهٔ رشد و نمو و طول عمر کفشدوزک‌های بالغ ماده به ترتیب روی میزبان‌های گیاهی ذرت و لوبیا چشم بلبلی و بیشترین آن روی گیاه کرچک ثبت شد. در حالی‌که کمترین مقدار باروری، نرخ خالص تولیدمثل (R_0) و نرخ ذاتی افزایش جمعیت (r) به ترتیب ۱۱/۴۹±۱۰۷/۶۵ نتاج (تخم)، ۴/۴۱±۲۰/۶۳ نتاج (تخم) و ۰/۰۰۷۲±۰/۱۰۰۱ (بر روز) روی کرچک و بیشترین مقدار پراسنجه‌های ذکر شده به ترتیب ۲۰/۱۸±۱۵۸/۶۷ تخم، ۸/۴۷ ± ۴۳/۶۳ تخم و ۰/۰۰۶۹± ۰/۱۴۴۸ بر روز روی گیاه ذرت برآورد شد. شد. نتایج بدست آمده، اثرات معنی‌دار نوع گیاهان میزبان و گونه‌های شکار روی طول دورهٔ رشد و نمو و پراسنجه‌های جمعیت‌نگاری کفشدوزک شکارگر *S. gilvifrons* را اثبات کرد. نتایج حاصل از پژوهش حاضر، در راستای پرورش انبوه کفشدوزک *S. gilvifrons* و درک بهتر تغییرات جمعیت آن تحت تاثیر گونهٔ شکار و گیاهان میزبان، مفید و قابل استفاده خواهد بود.