J. Agr. Sci. Tech. (2016) Vol. 18: 179-190

Bottom-up Effect of Two Host Plants on Life Table Parameters of *Aphis gossypii* (Hemiptera: Aphididae)

Z. Tazerouni[1], A. A. Talebi[1*], Y. Fathipour[1], and M. Soufbaf[2]

ABSTRACT

Aphis gossypii **Glover is one of the most important pests of greenhouse cucumber and pepper in the world and Iran. In this research, life table and biology of *A. gossypii* were investigated on cucumber (*Cucumis sativus* cv. Super Sultan) and pepper (*Capsicum annum* cv. Marqueza) in a growth chamber at 25±1°C and 60±5% RH and a photoperiod of 14 L: 10 D hour. The results showed that developmental time of *A. gossypii* on pepper was significantly longer than that on cucumber. The survival rates of *A. gossypii* on cucumber and pepper were significantly different based on Kolmogrov-Smirnov test results. The survival rates (l_x) at the beginning of female emergence were 94 and 66% on cucumber and pepper, respectively. Life expectancy (e_x) of the newly-born nymphs of *A. gossypii* were obtained as 26.37 and 14.4 days on cucumber and pepper, respectively. The highest age-specific daily fecundity of *A. gossypii* was at the 5th and 6th days of female adult age on cucumber and from first to 4th days of female adult life on pepper. Furthermore, two mathematical models (Analytis and Enkegaard) were fitted to age-specific fecundity data (m_x). Adult longevity of *A. gossypii* on cucumber was significantly higher than that on pepper. The R_0, r_m and λ-values of *A. gossypii* on cucumber were significantly higher than those on pepper. The cotton aphid exhibited longer mean generation time (T) on pepper than that on cucumber. According to the growth index and life table statistics, cucumber was the suitable host plant for *A. gossypii*.**

Keywords: Aphid, Cucumber, Demography, Iran, Pepper.

INTRODUCTION

Cucumber, *Cucumis sativus* L. (Cucurbitaceae), and pepper, *Capsicum annum* L. (Solanaceae) are the most important vegetables in most regions of the world (Trdan *et al*., 2007; Laznik *et al*., 2011). Aphids are an extremely successful group of insects which occur throughout the world, with the greatest number of species in the temperate regions (Žanić *et al*., 2013). *Aphis gossypii* Glover (Hemiptera: Aphididae) is a major economic pest that attack greenhouse vegetable crops (van Lenteren and Woets, 1988; van Steenis, 1993) throughout the world and Iran (van Steenis, 1992; Baniameri and Nasrollahi, 2003). This aphid damages crop plants directly by sucking plant sap, particularly when its population is high and indirectly by transmission of plant viruses (Dixon, 1973; Agrios, 1988; Matthews, 1991). Several plant viruses transmitted by *A. gossypii* may impart economically important damages on vegetable crops including *Cucumber Mosaic Virus* (CMV), *Potato Virus Y* (PVY), *Tobacco Etch Virus* (TEV), *Papaya Ring-spot Virus-Type W* (PRV-W) and *Zucchini Yellow Mosaic Virus* (ZYMV) (Kennedy *et al*., 1962; Pinto *et al*., 2008).

[1] Deparment of Entomology, College of Agriculture, Tarbiat Modares University, P. O. Box: 14115-336, Tehran, Islamic Republic of Iran.
[*] Corresponding author; e-mail: talebia@modares.ac.ir
[2] Agricultural, Medical and Industrial Research School, P. O. Box: 31485/498, Karaj, Islamic Republic of Iran.

[DOR: 20.1001.1.16807073.2016.18.1.12.0]

Life table studies provide basic crucial information for population ecology and pest management. Life table gives the most comprehensive description of birth, survival rate, death, reproduction and finally population growth capacity of an insect (Southwood and Henderson, 2000).

The biology of cotton aphid, *A. gossypii* has been studied on cucumber (Negin variety) (Zamani *et al*., 2006; Takalloozadeh, 2010) and pepper (Kandil Dolma variety) (Satar *et al*., 2008). Several studies have also been performed to measure the potential of coccinellid predators in suppressing *A. gossypii* populations (Kianpour *et al*., 2010; Davoodi Dehkordi and Sahragard, 2013). However, the life table parameters of cotton aphid on cucumber (Super Sultan variety) and pepper (Marqueza variety) as newly common varieties of cucumber and pepper in greenhouses in Iran were not studied. Thus, the main objective of this study was to determine the effect of host plant on survival, development, longevity, reproduction and population growth parameters of *A. gossypii*.

MATERIAL AND METHODS

Insect and Plant Culturing

A. gossypii was collected on greenhouse-grown cucumber in the College of Agriculture, Tarbiat Modares University in Tehran, Iran, in December 2012. Aphids were colonized separately on *Cu. sativus cv.* Super Sultan and *Ca. annum cv.* Marqueza in growth chamber at 25±1°C, relative humidity of 60±5% and a photoperiod of 14 L: 10 D hour. The cotton aphid clone reared in laboratory conditions for several generations (3 months) was used in the experiments (Kindlmann and Dixon, 1989). Seedlings of cucumber and pepper were planted in a mixture of sand (25%), clay (25%), perlit (25%) and manure (25%) in 25 cm pots.

Experimental Design

To studyidemographic parameters of cotton aphid on cucumber, a wingless female of *A. gossypii* was randomly selected from the stock culture transferred individually on cucumber leaf with 50 mm diameter on a layer of wet cotton wool in plastic container (75×60×40 mm). The container was covered with micromesh for ventilation. After 24 hours, adult females of *A. gossypii* were removed and only one newly-born nymph was maintained in each leaf disc. The nymphs on each leaf disc was checked daily and their survival recorded. The presence of the discarded exuviate was used to determine time of molting. When the immature nymphs changed into adults, they were observed daily for reproduction and survival and all new-born nymphs were counted and removed from each leaf cage. The observations continued until the death of all examined aphids. To reduce the effects of plant age on aphid development and survivorship, the cotton wool in the container was moistened daily and aphids were transferred every 5 days on a new cucumber leaf disc (McCornack *et al*., 2004). The experiment was replicated 150 times.

Life table parameters of cotton aphid were also investigated on pepper leaf discs similar to method explained earlier.

Assessment of Trichome

To investigate the presence or absence of trichome on cucumber and pepper leaves, the lower surface of cucumber and pepper leaves was used, because *A. gossypii* preferred to feed on the lower surface of the host plants. Images of the lower of surface of leaves were taken with an Olympus TM SZX9 stereomicroscope equipped with a Sony CCD digital camera.

Age-specific Fecundity Models

Age-specific fecundity (m_x) was fitted to both Analytis (Analytis, 1977) [Equation

(1)] and Enkegaard (Enkegaard, 1993) [Equation (2)] models:

$m_x = p(x - x_{\min})^n \times (x_{\max} - x)^m$ (1)

$m_x = (a+bx) \times \exp[-(c+dx)]$ (2)

Where, x is the female age (day). Estimated parameters of non-linear models including x_{min}, x_{max}, p, n, m, a, b, c and d were determined using JMP software (SAS Institute, 2007). The coefficient of determination (R^2) and adjusted coefficient of nonlinear regression (R^2_{adj}) were used to assess the goodness of fit of each model. *AIC* (Akaike Information Criterion) (Akaike, 1974) and *BIC* (Bayesian Information Criterion) (Schwarz, 1978) are other goodness-of-fit parameters that were calculated by the following equations (Vucetich *et al*., 2002):

$AIC = n \times \ln(SSE/n) + 2p$

$BIC = n \times \ln(SSE/n) + (p \times \ln(n))$

Where, n is the number of days of female age, p is the number of parameters estimated in each model and the *SSE* is the sum of squared error.

Statistical Analyses

The life table parameters including the survival rate (l_x), life expectancy (e_x), entropy parameter (H), net reproductive rate (R_0), intrinsic rate of increase (r_m), finite rate of increase (λ), mean generation time (T) and Doubling Time (DT) were calculated using the formulas suggested by Birch (1948), Southwood and Henderson (2000) and Carey (1993, 2001) as follows:

$$l_x = \frac{N_x}{N_0}$$

$$e_x = \frac{T_x}{l_x}$$

$$H = \frac{\sum_{x=0}^{\omega} e_x d_x}{e_0}$$

$$d_x = l_x - l_{x+1}$$

$$R_0 = \sum_{x=\alpha}^{\beta} l_x m_x$$

$$1 = \sum_{x=1}^{\omega} e^{-rx} l_x m_x$$

$$\lambda = e^r$$

$$T = \frac{\ln R_0}{r}$$

$$DT = \frac{\ln 2}{r}$$

Where, x is the age in days, N_x is number alive at age x, N_0 is the initial number of individuals in the cohort, T_x is the number of time units lived by the cohort from age x until the death of all cohort individuals, e is the base of natural logarithm, β is the maximum age among n individuals, α is the pre-imaginal development time and m_x is the age-specific number of female offspring. If H is < 0.5, = 0.5 or > 0.5, the survival schedule would be convex, linear and concave, respectively. If H= 0, then all deaths occur at exactly the same age and if H= 1, then the shape of survival schedule would be exponentially declining. Age specific survival rates (l_x) of *A. gossypii* on cucumber and pepper were compared by Kolmogorove-Smirnove test (P< 0.05) (Pyke and Thomson, 1986).

To estimate the variance for r_m and other population growth parameters, the jackknife method was used (Meyer *et al.,* 1986). In this method, the pseudo-value for each parameter such as $r_{m(i)}$ was estimated by using the following equation (Maia *et al*., 2000):

PSV $r_{m(i)} =](n \times r_{m(\text{all})}) - (n-1)] \times r_{m\,(i)}$

Where, $r_{m(i)}$ is the value for (n-1) females. The mean values of Jackknife pseudo-values for two host plants (cucumber and pepper) were subjected to analysis of *t*-test. Similar procedures were used for other population growth parameters.

Statistical analysis was carried out using SAS (SAS Institute, 2003). The differences in population growth parameters of cotton aphid on cucumber and pepper were compared using *t*-test (P_{value}< 0.05) using SPSS 18 (SPSS, 2009).

RESULTS

Developmental Time

The duration of the different nymphal instars of *A. gossypii* on the two host plants are presented in Table 1. Host plant significantly affected aphid nymphal developmental time. The developmental time of *A. gossypii* on pepper was significantly slower than that on cucumber (t= -5.454, df= 99.118, P< 0.05). Significant differences were found among the duration of first (t= -6.020, df= 269.907, P< 0.05), second (t= -4.589, df= 143.924, P< 0.05), third (t= -4.050, df= 104.151, P< 0.05) and fourth (t= -2.321, df= 100.506, P< 0.05) nymphal instar periods.

Age-specific Survival Rate, Entropy Parameter and Life Expectancy

The age-specific survival rate of *A. gossypii* on cucumber and pepper was compared using Kolmogrov-Smirnov test (P< 0.05). The survival rates of *A. gossypii* on cucumber and pepper were significantly different (Z= 4.761, P< 0.001) (Figure 1-a). The survival of *A. gossypii* at the time of female emergence was 94 and 66% on cucumber and pepper, respectively. Survivorship of aphid decreased more quickly to zero on pepper. The maximum mortality in immature stages of *A. gossypii* on cucumber and pepper were observed during second (2.7%) and first (30.7%) nymphal instars, respectively.

The entropy (H) of *A. gossypii* on cucumber and pepper were 0.266 and 0.628, respectively. These results suggested that the survival schedule of *A. gossypii* was convex (H< 0.5) on cucumber and concave (H> 0.5) on pepper and corresponds to Deevey's type I and III survivorship curves on cucumber and pepper, respectively.

Life expectancy (e_x) of *A. gossypii* was obtained as 26.37 and 14.4 days on cucumber and pepper, respectively at the beginning of life (Figure 1-b). The life expectancy of newly emerged adults of *A. gossypii* was estimated to be 23.92 and 16.08 days on cucumber and pepper, respectively.

Adult Longevity and Fecundity

The pre-nymphipositional period of *A. gossypii* was not affected significantly by the host plant (t= -1.948, df= 89.609, P> 0.05) (Table 2). The nymphipositional period is defined as the number of days from the first to last birth per mother aphid and *t*-test showed a significant difference between nymphipositional period of *A. gossypii* on cucumber and pepper (t= 2.404, df= 187.868, P< 0.05). The values of post-nymphipositional period and adult longevity of *A. gossypii* on cucumber were higher than those on pepper (t= 11.912, df= 158.929, P< 0.05; t= 8.408, df= 192.105, P< 0.05).

Figure 2 shows the age-specific fecundity (m_x) curves of *A. gossypii* on cucumber and pepper. These curves revealed that the age-specific fecundity schedule fluctuated throughout the nymphipositional period. The results showed that the highest efficiency of *A. gossypii* to produce offspring on cucumber was at 5th and 6th days of adult female age, while it was highest from first to 4th days of

Table 1. The mean (±SE) duration (days) of different nymphal instars of *Aphis gossypii* on two host plants.[a]

Host plant	Life stages				
	1st instar	2nd instar	3rd instar	4th instar	Pre-immaginal period
Cucumber	1.28±0.038^b	1.09±0.024^b	1.05±0.018^b	1.04±0.017^b	4.48±0.046^b
Pepper	1.68±0.054^a	1.36±0.054^a	1.28±0.054^a	1.15±0.044^a	5.20±0.125^a

[a] Means in the same column followed by the same letters do not differ significantly (P< 0.05) by the *t-test*.

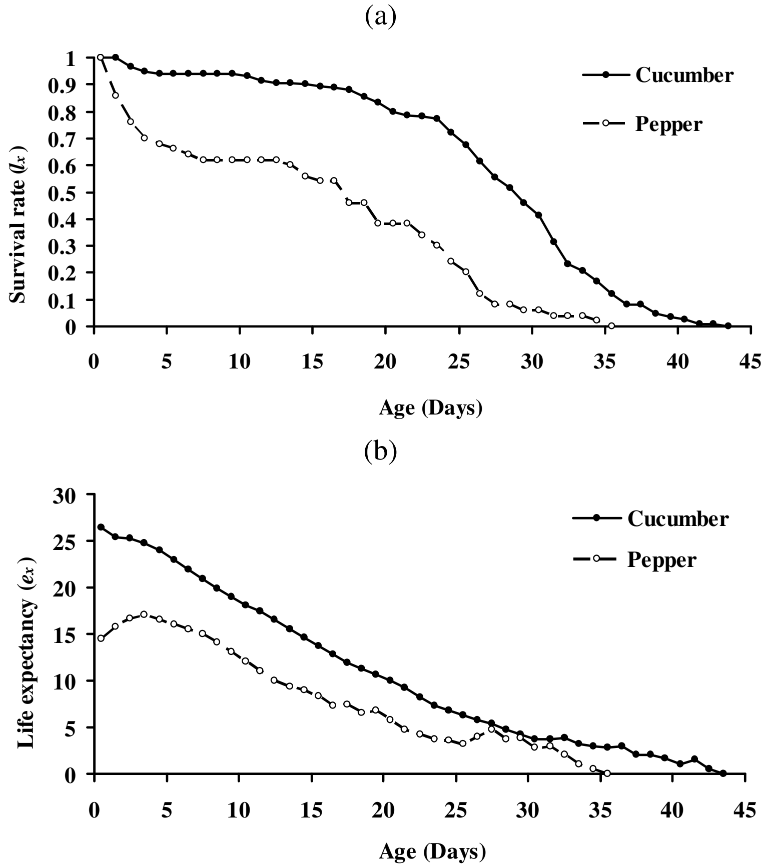


Figure 1. Age-specific survival rate (l_x) (a) and life expectancy (e_x) (b) of *Aphis gossypii* on cucumber and pepper.

adult life on pepper. Furthermore, Analytis and Enkegaard models fitted well the age-specific fecundity of cotton aphid on cucumber and pepper (Figure 2). The parameters of these models and the values of fitted coefficients of evaluated models for describing cotton aphid age-specific fecundity are shown in Table 3.

Life Table Parameters

Effects of host plant on population growth parameters of cotton aphid are listed in Table 4. The net reproductive rate (R_0) was obtained to be 80.61 and 13.21 (female offspring) on cucumber and pepper, respectively. The R_0-value of *A. gossypii* on cucumber was significantly higher than that on pepper (t= 31.224, df= 164.068, P< 0.01).

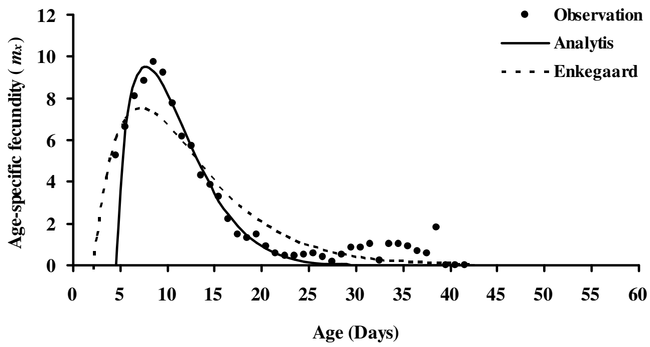
Table 2. Adult longevity and reproductive period (days±SE) for females of *Aphis gossypii* on two host plants.[a]

Host plant	Pre-nymphipositional Period	Nymphipositional Period	Post-nymphipositional Period	Adult longevity
Cucumber	0.01±0.009[a]	17.04±0.515[a]	5.89±0.423[a]	22.94±0.568[a]
Pepper	0.09±0.003[a]	15.19±0.569[b]	0.67±0.112[b]	15.95±0.608[b]

[a] Means in the same column followed by the same letters do not differ significantly (P< 0.05) by the *t-test.*

[DOR: 20.1001.1.16807073.2016.18.1.12.0]

(a)



(b)

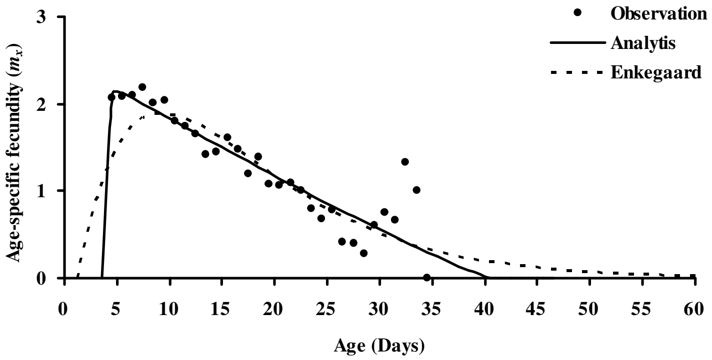


Figure 2. Analytis and Enkegaard models fitted to the age-specific fecundity (m_x) of *Aphis gossypii* on cucumber (a) and pepper (b).

Table 3. Values of fitted coefficients, measurable parameters and evaluation of two nonlinear models to describe age-specific fecundity of *Aphis gossypii* on cucumber and pepper.

Model	Parameters[a]	Host plant	
		Cucumber	Pepper
Analytis	p	186×10^{-14}	0.0367
	x_{min}	4.5234	4.4998
	x_{max}	42.5074	40.6928
	m	0.7301	0.0047
	n	8.0049	1.1404
	R^2	0.964	0.814
	R^2_{adj}	0.960	0.785
	AIC	-35.163	-76.264
	BIC	-26.850	-69.094
Enkegaard	a	-35.8333	-1.9799
	b	16.7868	1.5788
	c	0.9814	0.7460
	d	0.2004	0.1242
	R^2	0.957	0.702
	R^2_{adj}	0.953	0.669
	AIC	-30.603	-49.307
	BIC	-23.949	-49.307

[a] R^2: Coefficient of determination; R^2_{adj}: Adjusted R^2; *AIC*: Akaike Information Criterion, *BIC*: Bayesian Information Criterion.

Table 4. Effect of two host plants on life table parameters (±SE) of *Aphis gossypii*.[a]

Host plant	Parameters					
	R_0	r_m	λ	T	DT	GI^b
Cucumber	80.61±2.067[a]	0.493±0.008[a]	1.62±0.017a	9.07±0.215[b]	1.43±0.030[b]	0.21±0.004[a]
Pepper	13.21±0.622[b]	0.250±0.006[b]	1.28±0.008[b]	10.33±0.222[a]	2.77±0.070[a]	0.10±0.011[b]

[a] Same letters in the columns indicate no significant (P< 0.05) differences between host plants by the *t-test*.
[b] *GI* (Growth Index), computed as the ratio between the percentages of adults emerged and the duration of the immature period (Ramasubramanian and Babu, 1989).

(a) (b)

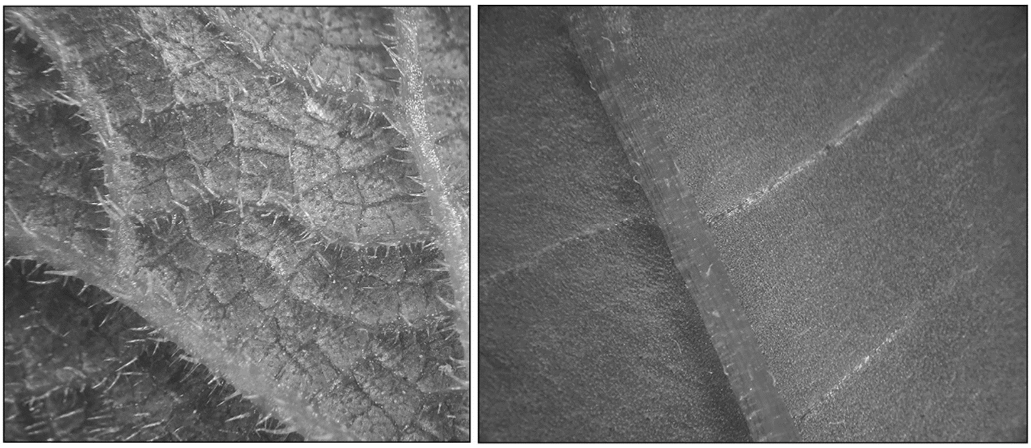


Figure 3. The lower surfaces of cucumber (a) and pepper (b) leaves.

The intrinsic rate of natural increase of *A. gossypii* was found to be 0.493 and 0.250 (day^{-1}) on cucumber and pepper, respectively, with a significant difference (t= 23.272, df= 215.967, P< 0.01). The cotton aphid exhibited longer mean generation time (T) on pepper than on cucumber (t= -4.061, df= 196.749, P< 0.01). The Growth Index (*GI*) on cucumber was about twice as high as on pepper (t=9.250, df= 2.393, P<0.01). Higher r_m, λ (finite rate of increase) (1.62 day^{-1}) and *GI* and lower *T* (9.07 day) and *DT* (Doubling Time) (1.43 day) on cucumber indicated that cucumber was a suitable host for *A. gossypii* (Table 4). According to the results (Table 4), the R_0 and r_m parameters of *A. gossypii* were significantly higher on cucumber than those on pepper. To some extent, this may be attributed to foliar pubescence (trichome density) in cucumber. The trichomes of lower surfaces of cucumber and pepper leaves are shown in Figure 3.

DISCUSSION

Host plants and temperature influence growth, survival and reproduction of insects (Bellows *et al.*, 1992; Žnidarčič *et al.*, 2008, 2011). The results of this research showed the obvious effect of host plant on development and fecundity of *A. gossypii.* The developmental period of cotton aphid on cucumber (4.48 day) was significantly shorter than that on pepper (5.20 day). Difference in development of *A. gossypii* on cucumber and pepper could be due to leaf trichome density and secondary metabolites (Dixon, 1998; Zarpas *et al*., 2006). The results of this study showed that trichomes as a physical factor on cucumber leaves are correlated with higher rates of aphid reproduction. Several studies have shown that the effect of trichomes on herbivores may be positive; for example, McAuslane (1996) reported that *Bemisia* *tabaci* (Gennadius) significantly laid more eggs on pubescent soybean than on glabrous soybean. Also the research done by Srinivasan and Uthamasamy (2005) showed that the influence of trichomes in tomato leaves was correlated with the possible resistance to *Helicoverpa armigera* (Hübner) and *B. tabaci*. Oriani and Vendramim (2010) explained that ovipositional preference of *B. tabaci* for tomato can associated with trichomes density on the leaves of different genotypes. The number of aphid [*Sipha maydis* (Passerini)] on Pishtaz (wheat cultivar) was significantly greater than that on other cultivars at 48 h after infestation, because Pishtaz had the maximum density of trichomes compared to the other cultivars (Gholami Moghadam *et al*., 2013).

The negative effect of trichomes on ovipositional preference, eggs laid and number of herbivores were reported by Eisner *et al*., 1998; Khan *et al*., 2000; Lam and Pedigo, 2001; Pompon *et al*., 2010 and Žnidarčič *et al*., 2008, 2011. Differences in the effect of trichomes on herbivores may be related to pest species. The percentage of nymphal mortality of *A. gossypii* on cucumber in this research was 6%. The survival data of cotton aphid in this study is partially close to Zamani *et al*. (2006). In the present research, percentage nymphal mortality of *A. gossypii* on pepper was 34% while Satar *et al*. (2008) reported that the survival rate of *A. gossypii* at the beginning of adult emergence on pepper was 100%. In this research, the entropy parameter of *A. gossypii* was lower and higher than 0.5 on cucumber and pepper, respectively. Our findings showed that maximum death probability of *A. gossypii* on cucumber was in older ages compared with early ones, while the death probability of cotton aphid on pepper was higher in earlier ages. These findings are in agreement with the survival curves (Figure 1-a). The Analytis and Enkegaard models are frequently fitted to age-specific fecundity (Kontodimas *et al*., 2007). These models gave a satisfactory fit to observed data on cucumber and pepper indicated by high values of R^2_{adj} (Table 3). The results showed that the age-specific fecundity data of *A. gossypii* on the two host plants fitted better with Analytis than Enkegaard model based on *AIC, BIC* and successful convergence (Table 3). However, it seems that the Enkegaard model slightly underestimates the peak of age-specific fecundity of *A. gossypii* on cucumber and pepper (Figure 2). In addition, the end of nymphipositional period of *A. gossypii* on pepper was predicted longer than the observed data by Enkegaard model (Figure 2).

The estimated R_0 value of cotton aphid on cucumber in the current study was 80.61 female offspring. The net reproductive rate of *A. gossypii* on cucumber (Negin variety) was 57.07 (Zamani *et al*., 2006), which is lower than that obtained in the current study. Takalloozadeh (2010) obtained net fecundity rate of *A. gossypii* 61.201 and 46.096 on cucumber and cotton, respectively. In this research, net fecundity rate of *A. gossypii* on pepper was 13.21 female offspring, while Satar *et al*. (2008) found 60.76 female offspring. The r_m is the most important parameter for describing the growth potential of a population under given climatic and food conditions as this parameter reflects an overall effect on development, fecundity and survival (Southwood and Handerson, 2000). Other researchers have reported the r_m values of *A. gossypii* from 0.129 to 0.482 depending on temperature and host plant (Komazaki, 1982; Shi, 1985; Satar *et al*., 1998, 1999, 2008; Kersting *et al*. 1999; Xia *et al*. 1999; Razmjou *et al*. 2006; Zamani *et al*. 2006; Rahman *et al*., 2009; Takalloozadeh, 2010). In this study, the r_m of aphid populations reared on cucumber was (0.493 day^{-1}) greater compared with those obtained in other researches. But the r_m-value of *A. gossypii* reared on pepper in the current study (0.250 day^{-1}) obviously falls within this range.

There are differences between biological characteristics and life table parameters of cotton aphid on cucumber and pepper obtained here and those data reported in other researches (Razmjou *et al*., 2006; Zamani *et al*., 2006; Satar *et al*., 2008; Rahman *et al*., 2009; Takolloozadeh, 2010). These differences may be related to variations in geographic populations involved, methodology and cultivars used. Plant species differ greatly in suitability as hosts for specific insects when measured in terms of survival, development and reproductive rates of the pest. Shorter development times and greater total reproduction of insects on a host plant indicate greater suitability (van Lenteren and Noldus 1990). Also, significant differences were observed in the performance of *A. gossypii* on cucumber and pepper. It can be concluded that cucumber was a suitable host for *A. gossypii* based on the fast development and the high intrinsic rate of increase. However, further physiological and biochemical investigations are required to better understand bottom-up effects of mentioned host plants on the life history of *A. gossypii*.

ACKNOWLEDGEMENTS

The authors are grateful to the Department of Entomology, Tarbiat Modares University, for financial support and providing required facilities to carry out this project. We cordially thank three anonymous reviewers for their valuable comments and recommendations on the earlier version of this paper.

REFERENCES

1. Agrios, G. N. 1988. *Plant Pathology*. Academic Press, San Diego, 803 PP.
2. Akaike, H. 1974. A New Look at the Statistical Model Identification. *IEEE Trans. Automat. Contr.,* **19**: 716-723.
3. Analytis, S. 1977. U¨ber die Relation Zwischen Biologischer Entwicklung und Temperatur bei Phytopathogenen Pilzen. *J. Phytopatho.,* **90**: 64–76.
4. Baniameri, V. and Nasrollahi, A. A. 2003. Status of IPM Program in Greenhouse Vegetables in Iran. *IOBC/WPRS Bull.*, **26**: 1–3. (Additional Abstracts/Papers)
5. Bellows, T. S. J., van Driesche, R. G. and Elkinton, J. S. 1992. Life Table Construction and Analysis in the Evaluation of Natural Enemies. *Ann. Rev. Entomol.*, **37**: 587–614.
6. Birch, L. C. 1948. The Intrinsic Rate of Natural Increase of an Insect Population. *J. Anim. Ecol.*, **17**: 15–26.
7. Carey, J. R. 1993. Applied Demography for Biologists, with Special Emphasis on Insects. Oxford University Press, UK, 206 pp.
8. Carey, J. R. 2001. Insect Biodemography. *Ann. Rev. Entomol.*, **46**: 79-110.
9. Davoodi Dehkordi, S. and Sahragard, A. 2013. Functional Response of *Hippodamia variegata* (Coleoptera: Coccinellidae) to Different Densities of *Aphis gossypii* (Hemiptera: Aphididae) in an Open Patch Design. *J. Agr. Sci. Tech.*, **15(4)**: 651-659.9.
10. Dixon, A. F. G. 1998. *Aphid Ecology*. Chapman and Hall, London, 300 pp.
11. Dixon, A. F. G. 1973. *Biology of Aphids*. Edward Arnold, London, 58 pp.
12. Eisner, T., Eisner, M. and Hoebeke, E. R. 1998. When Defense Backfires: Detrimental Effect of a Plant's Protective Trichomes on an Insect Beneficial to the Plant. *P. Natl. Acad. Sci.,* **95**: 4410-4414.
13. Enkegaard, A. 1993. The Poinsettia Strain of the Cotton Whitefly, *Bemisia tabaci* (Homoptera: Aleyrodidae), Biological and Demographic Parameters on Poinsettia (*Euphorbia pulcherrima*) in Relation to Temperature. *Bull. Entomol. Res.*, **83**: 535–546.
14. Gholami Moghadam, S., Hosseini, M. and Modares Awal, M. 2013. Does Leaf Pubescence of Wheat Affect Host Selection and Life Table Parameters of *Sipha maydis* (Hemiptera: Aphididae)? *J. Crop. Prot.,* **2(1)**: 81-92.
15. Kennedy, J. S., Day, M. F. and Eastop, V. F. 1962. *A Conspectus of Aphids as Vectors as Plant Viruses.* Commonwealth Agricultural Bureaux, London, 114 PP.
16. Kersting, U., Satar, S. and Uygun, N. 1999. Effect of Temperature on Developmnt Rate and Fecundity of Apterous *Aphis gossypii* (Hom.: Aphididae) Reared on *Gossypium hirsutum* L. *J. Appl. Entomol.*, **123**: 23-27.
17. Kianpour, R., Fathipour, Y., Kamali, K. and Naseri, B. 2010. Bionomics of *Aphis gossypii* (Homoptera: Aphididae) and its Predators *Coccinella septempunctata* and *Hippodamia variegata* (Coleoptera: Coccinellidae) in Natural Conditions. *J. Agr. Sci. Tech.*, **12(1)**: 1-11.
18. Khan, M. M., Kundu, R. and Alam, M. Z. 2000. Impact of Trichome Density on the Infestation of *Aphis gossypii* Glover and Incidence of Virus Dsease in Ashgourd

Benincasa hispida (Thunb.). *Inter. J. Pest. Manag*e., **46**: 201-204.

19. Kindlmann, P. and Dixon, A. F. G. 1989. Development Constraints in the Evolution of Reproductive Strategies: Telescoping of Generations in Parthenogenetic Aphids. *Funct. Ecol.*, **3**: 531-537.
20. Komazaki, S. 1982. Effects of Constant Temperature on Population Growth of Three Aphid Species, *Toxoptera citricidus* (Kirkaldy), *Aphis citricola* van der Goot and *Aphis gossypii* Glover (Homoptera: Ahididae) on Citrus. *Appl. Entomol. Zool.*, **17**: 75-81.
21. Kontodimas, D. C., Milonas, P. G., Stathas, G. J., Economou, L. P. and Kavallieratos, N. G. 2007. Life Table Parameters of the Pseudococcid Predators *Nephus includens* and *Nephus bisignatus* (Coleoptera: Coccinelidae). *Eur. J. Entomol.*, **104**: 407–415.
22. Lam, W. K. F. and Pedigo, L. P. 2001. Effect of Trichome Density on Soybean Pod Feeding by Adult Bean Leaf Beetles (Coleoptera: Chrysomelidae). *J. Econ. Entomol.*, **94**: 1459-1463.
23. Laznik, Ž., Žnidarčič, D. and Trdan, S. 2011. Control of *Trialeurodes vaporariorum* (Westwood) Adults on Glasshouse-grown Cucumbers in four Different Growth Substrates: An Efficacy Comparison of Foliar Application of *Steinernema feltiae* (Filipjev) and Spraying with Thiamethoxamn. *Turk. J. Agric. For.,* **35(6)**: 631-640.
24. McAuslane, H. J. 1996. Influence of Leaf Pubescence on Ovipositional Preference of *Bemisia argentifolii* (Homoptera: Aleyrodidae) on Soybean. *Environ. Entomol.*, **25**: 834-841.
25. Maia, A. H. N., Luiz, A. J. B. and Campanhola, C. 2000. Statistical Influence on Associated Fertility Life Table Parameters Using Jackknife Technique: Computational Aspects. *J. Econ. Entomol.*, **93**: 511–518.
26. Matthews, R. E. F. 1991. *Plant Virology*. Academic Press, New York, 835 PP.
27. McCornack, B. P., Ragsdale, D. W. and Venette, R. C. 2004. Demography of Soybean Aphid (Hom.: Aphididae) at Summer Temperatures. *J. Econ. Entomol.*, **97**: 854–861.
28. Meyer, J. S., Ingersoll, C. G., McDonald, L. L. and Boyce, M. S. 1986. Estimating Uncertainly in Population Growth Rates: Jackknife vs. Bootstrap Techniques. *Ecol.,* **67**: 1156–1166.
29. Oriani, M. A. D. G. and Vendramim, J. D. 2010. Influence of Trichomes on Attractiveness and Ovipositional Preference of *Bemisia tabaci* (Genn.) B Biotype (Hemiptera: Leyrodidae) on Tomato Genotypes. *Neotrop. Entomol.*, **39**: 1002-1007.
30. Pinto, Z. V., Rezende, J. A. M., Valdir Atsushi Yuki, V. A. and Piedade, S. M. S. 2008. Ability of *Aphis gossypii* and *Myzus persicae* to Transmit *Cucumber Mosaic Virus* in Single and Mixed Infection with Two Potyviruses to Zucchini Squash. *Summa. Phytopathol. Botucatu.*, **34(2)**: 183-185.
31. Pompon, J., Quiring, D., Giordanengo, Ph. and Pelletier, Y. 2010. Role of Host-Plant Selection in Resistance of Wild Solanum Species to *Macrosiphum euphorbiae* and *Myzus persicae*. *Entomol. Exp. Appl.*, **137**: 73-85.
32. Pyke, D. A. and Thampson, J. N. 1986. Statistical Analysis of Survival and Removal Rate Experiments. *Ecol.,* **67(1)**: 240-245.
33. Rahman, M. M., Sarker, P. K. and Das, B. Ch. 2009. Intrinsic Rate of Increase (r_m) of *Aphis gossypii* Glover Infesting Brinjal Plants. *J. Biol. Sci.,* **17**: 123-127.
34. Ramasubramanian, G. V. and Babu, P. C. S. 1989. Comparative Biology of the Spotted Pod Borer, *Maruca testulalis* (Geyer) on Three Host Plants. *Legum. Res.,* **12**: 177–178.
35. Razmjou, J., Moharramipour, S., Fathipour, Y. and Mirhoseini, S. Z. 2006. Effect of Cotton Cultivar on Performance of *Aphis gossypii* (Homoptera: Aphididae) in Iran. *J. Econ. Entomol.*, **99**: 1820–1825.
36. SAS Institute. 2003. GLM: A Guide to Statistical and Data Analysis, Version 9.1. SAS Institute, Cary, NC.
37. SAS Institute. 2007. *JMP: A Guide to Statistical and Data Analysis, Version 7.0.1*. Computer Program, SAS Institute, Cary, NC.
38. Satar, S., Kersting, U. and Uygun, N. 2008. Effect of Temperature on Population Parameters of *Aphis gossypii* Glover and *Myzus persicae* (Sulzer) (Homoptera: Aphididae) on Pepper. *J. Plant. Dis. Protect.*, **115(2)**: 69–74.

[DOR: 20.1001.1.16807073.2016.18.1.12.0]

39. Satar, S., Kersting, U. and Uygun, N. 1998. Effect of Different Citrus Host Plants and Temperatures on Development Rate and Fecundity of Apterous *Aphis gossypii* Glover (Homoptera: Aphididae). *Türk. Entomol. Dern.*, **22**: 187-197.
40. Satar, S., Kersting, U. and Uygun, N. 1999. Development and Fecundity of *Aphis gossypii* Glover (Homoptera: Aphididae) on Three Malvaceae Hosts. *Turk. J. Agric. For.*, **23**: 637-643.
41. Schwarz, G. 1978. Estimating the Dimension of a Model. *Ann. Stat.*, **6**: 461-464.
42. Shi, D. S. 1985. Studies on the Parasitoid of Cotton Aphid. II. Population Suppression by Two Primary Parasitoids on Cotton Aphid. *Contr. Shanghai. Inst. Entomol*, **5**: 95- 103.
43. Southwood, T. R. E. and Henderson, P. A. 2000. *Ecological Methods*. 3rdedition. Blackwell, Oxford, United Kingdom. 592 pp.
44. SPSS. 2009. *SPSS Base18.0 Users Guide.* SPSS, Chicago, IL.
45. Srinivasan, R. and Uthamasamy, S. 2005. Trichome Density and Antibiosis Affect Resistance of Tomato to Fruitborer and Whitefly Under Laboratory Conditions. *J. Veg. Sci.*, **11**: 3-17.
46. Takalloozadeh, H. M. 2010. Effect of Host-Plants and Various Temperatures on Population Growth Parameters of *Aphis gossypii* Glover (Hom.: Aphididae). *Middle-East. J. Sci. Res.,* **6(1)**: 25-30.
47. Trdan, S., Žnidarčič, D. and Vidrih, M. 2007. Control of *Frankliniella occidentalis* on Greenhouse-grown Cucumbers: An Efficacy Comparison of Foliar Application of *Steinernema feltiae* and Spraying with Abamectin. *Russ. J. Bematol.*, **15(1)**: 25-34.
48. van Lenteren, J. C. and Noldus, L. P. J. J. 1990. Whitefly-plant Relationship: Behavioral and Biological Aspects. In: "*Their Bionomics, Pest Status and Management Whitefly*", (Ed.): Gerling, D.. Intercept, Andover, PP. 47–89.
49. van Lenteren, J. C. and Woets, J. 1988. Biological and Integrated Pest Control in Greenhouses. *Ann. Revi. Entomol.*, **33**: 239-269.
50. van Steenis, M. J. 1992. Biological Control of the Cotton Aphid, *Aphis gossypii* Glover (Hom., Aphididae): Pre-Introduction Evaluation of Natural Enemies. *J. Appl. Entomol.*, **114**: 362-380.
51. van Steenis, M. J. 1993. Suitability of *Aphis gossypii* Glov., *Macrosiphum euphorbiae* (Thom.) and *Myzus persicae* Sulz. (Hom.: Aphididae) as Host for Several Aphid Parasitoid Species (Hym.: Braconidae). *SROP/WPRS Bull.*, **16**: 157-160.
52. Vucetich, J. A., Peterson, R. O. and Schaefer, C. L. 2002. The Effect of Prey and Predator Densities on Wolf Predation. *Ecol.,* **83**: 3003-3013.
53. Xia, J. Y., van der Werf, W. and Rabbinge, R. 1999. Influence of Temperature on Bionomics of Cotton Aphid, Aphis gossypii, on Cotton. *Entomol. Exp. Appl.*, **90**: 25–35.
54. Zamani, A. A., Talebi, A. A., Fathipour, Y. and Baniameri, V. 2006. Effect of Temprature on Biology and Population Growth Parameters of *Aphis gossypii* Glover (Homoptera, Aphididae) on Greenhouse Cucumber. *J. Appl. Entomol.*, **130**: 453-460.
55. Žanić, K., Ban, D., Gotlin Čuljak, T., Goreta Ban, S., Dumičić, G., Haramija, J. and Žnidarčič, D. 2013. Aphid Populations (Hemiptera:Aphidoidea) Depend of Mulching in Watermelon Production in the Mediterranean Region of Croatia. *Span. J. Agric. Res.,* **11(4)**: 1120-1128.
56. Zarpas, K. D., Margaritopoulos, J. T., Stathi, L. and Tsitsipis, J. A. 2006. Performance of Cotton Aphid *Aphis gossypii* (Hemiptera: Aphididae) Lineages on Cotton Varieties. *Inter. J. Pest. Manage.*, **52(3)**: 225-232.
57. Žnidarčič, D., Valič, N. and Trdan, S. 2008. Epicuticular Wax Content in the Leaves of Cabbage (*Brassica oleracea* L. var. Capitata) as a Mechanical Barrier against Three Insect Pests. *Acta. Agr. Slov.*, **91(2)**: 361-370.
58. Žnidarčič, D., Marković, D., Vidrih, R., Bohinc, T. and Trdan, S. 2011. Which Biophysical and Biochemical Factors May Contribute to Higher Resistance of Cabbage (*Brassica oleraceae* L. var. Capitata) to Attack of the Most Important Pests. *Acta. Agr. Slov.*, **97(2)**: 151-158.

تأثیر سطح دو میزبان گیاهی بر پارامترهای جدول زندگی شته *Aphis gossypii* (Hemiptera: Aphididae)

ز. تازرونی، ع. ا. طالبی، ی. فتحی پور، و م. سوف باف

چکیده

شته *Aphis gossypii* Glover یکی از مهم‌ترین آفات خیار و فلفل گلخانه‌ای در ایران و جهان است. در این تحقیق ویژگی‌های زیستی و پارامترهای جدول زندگی شته *A. gossypii* روی گیاه خیار، *Cucumis sativus*، رقم سوپر سلطان و گیاه فلفل، *Capsicum annum*، رقم مارکوئزا در اتاقک رشد با شرایط دمایی ۱±۲۵درجه سلسیوس، رطوبت نسبی ۵±۶۰٪ و دوره نوری ۱۴: ۱۰ (روشنایی : تاریکی) ساعت انجام شد. نتایج نشان داد طول دوره قبل از بلوغ شته *A. gossypii* روی گیاه فلفل نسبت به گیاه خیار با اختلاف معنی‌داری بیشتر است. آزمون Kolmogrov-Smirnov نشان داد، نرخ بقا شته *A. gossypii* روی دو گیاه خیار و فلفل اختلاف معنی‌داری دارد. نرخ بقا (l_x) در زمان ظهور افراد ماده روی گیاه خیار و فلفل به ترتیب ۹۴٪ و ۶۶٪ بود. امید به زندگی (e_x) پوره‌های تازه ظاهر شده شته *A. gossypii* روی گیاه خیار ۲۶/۳۷ روز و روی گیاه فلفل ۱۴/۴ روز به دست آمد. بیشترین میزان نرخ باروری روزانه شته *A. gossypii* روی گیاه خیار در افراد ماده ۵ و ۶ روزه و روی گیاه فلفل در ماده هایی که بین سنین یک تا ۴ روزه بودند مشاهده شد. همچنین مقادیر نرخ باروری روزانه (m_x) این شته با دو مدل ریاضی (Analytis و Enkegaard) برازش داده شدند. طول عمر افراد ماده بالغ شته *A. gossypii* روی گیاه خیار با اختلاف معنی‌داری نسبت به گیاه فلفل بیشتر بود. مقادیر R_0، r_m و λ شته *A. gossypii* روی گیاه خیار با اختلاف معنی‌داری نسبت گیاه فلفل بیشتر بود. میانگین مدت زمان هر نسل (T) شته جالیز روی گیاه فلفل به طور معنی‌داری نسبت به گیاه خیار بیشتر بود. با توجه به شاخص رشد و پارامترهای جدول زندگی، گیاه خیار نسبت به فلفل میزبان مناسب‌تری برای شته *A. gossypii* است.

[DOR: 20.1001.1.16807073.2016.18.1.12.0]