JCP

Comparing demographic parameters of *Serangium montazerii* (Coleoptera: Coccinellidae) on citrus whitefly, *Dialeurodes citri* (Hemiptera: Aleyrodidae) fed on two host plants

Seyedeh Masoumeh Fotukkiaii[1], Ahad Sahragard[1*] and Mohammad Fazel Halajisani[2]

1. Department of Plant Protection, College of Agriculture, University of Guilan, Rasht, Iran.
2. Iranian Citrus Research Center, Ramsar, Mazandaran Province, Iran.

Abstract: Demographic parameters of the ladybeetle, *Serangium montazerii* Fursch feeding on citrus whitefly, *Dialeurodes citri* Ashmead were determined on two host plants, Page tangerine and Thompson navel orange. This study was carried out under laboratory conditions (25 ± 1 °C and RH of 60 ± 5% and a photoperiod of 16: 8 h (L: D). Total pre-adult periods of the lady beetle were 20.84 ± 0.302, 19.27 ± 0.251days on Page tangerine and Thompson navel orange, respectively. The survivorship from egg to adult were very close to each other on the two host plants. The oviposition periods were 29.64 ± 0.905 and 33.36 ± 0.599 days and the total number of eggs per female (fecundity) were 457.14 ± 11.099 and 528.57 ± 12.369 on Page tangerine and Thompson orange, respectively. Peaks of reproductive value occurred at ages of 31 and 33 days when reared on Thompson navel orange and Page tangerine, respectively. The intrinsic rates of increase (*r*) on Thompson orange and on Page tangerine were 0.134 ± 0.063 and 0.126 ± 0.006d^{-1} with no significant differences. The mean generation time (*T*) on these host plants were 39.03 ± 0.5 and 40.57 ± 0.46 days, respectively. It can be concluded that *S. montazerii* feeding on *D. citri* in general showed a slightly better reproductive performance on Thompson navel orange than on Page tangerine.

Keywords: Generation time, intrinsic rate of increase, life table parameter, *S. montazerii*, survivorship.

Introduction

Whiteflies are among the most widespread and economically important insect pests worldwide (Greathead, 1986). *Dialeurodes citri* Ashmead (Hemiptera: Aleyrodidae) is one of the three economically important whiteflies on citrus in the Mediterranean region (Uygun *et al.* 1990; Rapisarda *et al.*, 1996). It is a polyphagous insect that attacks evergreen and deciduous

plants of 30 different families (Mound and Halsey, 1978). In the Mediterranean countries, it mainly lives on *Citrus* spp. and may cause serious damage, through extraction of large amounts of sap and the development of unsightly sooty mould on the abundant excreted honeydew (Žaniĉ *et al.*, 2001).

The activities of natural enemies can be influenced by the properties of the host plants of their prey, either directly or indirectly (Price *et al*., 1980; Southwood, 1986). A plant's nutritional value, secondary metabolites, and physical characteristics can affect the fecundity, population growth and survival of herbivorous insects (Slansky and Feeny, 1977; Norris and Kogan, 1980; Montllor, 1991;

Rutledge and O'Neil, 2005) and their predators (Letourneau, 1988; Cortesero *et al.*, 2000; Agrawal, 2000).

A large number of natural enemies are known to develop on *D. citri*, but only a few species are related to biological control. The lady beetles of the genus, *Serangium* Blackburn are widely distributed in the world and are known to be useful predators of many whitefly species (Asiimwe, 2007). The lady beetle, *S. montazerii* was recorded as a predator of the citrus whitefly, *D. citri* in Iran (Montazeri, 1994) and Turkey (Yigit *et al.*, 2003). This lady beetle seems to have a potential as a biocontrol agent of the cotton whitefly (Al-Zyoud, 2008). A successful biological control is achieved through calculating population growth rate, stage structure, fecundity, and predation rate of the pest's natural enemies like, predators. The demographic parameters of *S. montazerii* can provide a comprehensive description of the developmental times, survival rates of each growth stage, fecundity and can help predict the size of a population (Carey, 1993; Medeiros *et al.*, 2000; Southwood and Henderson, 2000). Collection of life table data for relevant species of different trophic levels in a food chain is a basic and important task for conservation (Bevill and Louda, 1999; Gabre *et al.*, 2005) and pest management (Naranjo, 2001). Estimating the growth parameters and reproduction potential of an insect population are essential requirements (Soroushmehr *et al.*, 2008). Most of the traditional female age-specific life tables (Lewis, 1942; Leslie, 1945; Birch, 1948) ignore the male population and the stage differentiation. Chi and Liu (1985) and Chi (1988) developed an age-stage two-sex life table theory. This life table theory takes the stage differentiation and the male population into consideration. Based on the age-stage, two-sex life table, Chi and Getz (1988) constructed a mass rearing program for stage structured populations. Timing of control of pest populations is possible using the age stage, two-sex life table (Chi, 1990).

The aim of this study was to determine the effects of two host plants on the life table parameters of *S. montazerii* feeding on *D. citri* under laboratory conditions.

Material and Methods

Insect culture
Page tangerine (*Citrus paradisi* × *C. reticulata*) × (*C. clementina*) and Thompson navel orange (*Citrus sinensis* cv. Thompson) varieties (Rutaceae) were used as the host plants in this study. More than 100 *S. montazerii* adults and about 1000 of *D. citri* adults were collected from citrus orchards in the Ramsar region, Mazandaran province (in northern Iran). Whiteflies were reared on a stock culture of above host plants in a greenhouse at Ramsar Citrus Research Center.

The collected ladybeetles were cultured for a generation on whiteflies that were fed on the leaves of the two host plants in a growth chamber at 25 ± 1 °C, 65 ± 5% relative humidity and a photoperiod of 16: 8 h (L: D). Then, adult predators were released on different nymphal stages of *D. citri* feeding on the leaves of the two host plants in Petri dishes (9 x 1 cm) for oviposition.

Life table study
Leaves bearing eggs of lady-beetles less than 12 h were placed in plastic Petri-dishes (9 cm in diameter) with a hole in the center of the lid, which was covered with muslin cloth for aeration and lined with 0.5 cm-thick layer of wetted cotton pad in the bottom of the Petri dish. The Petri-dishes were then placed in a growth chamber (with the condition mentioned earlier). The life table experiments were conducted on each host plant using 40 newly laid eggs of *S. montazerii*. Newly emerged larvae were then transferred to the Petri-dishes as above and reared individually on Thompson navel orange and Page tangerine leaves bearing eggs of *D. citri*. The host plants leaves bearing whiteflies eggs in each Petri-dish were replaced daily. Larval development and mortality were recorded every 24 h until the adult stage. After adult emergence, male and female were allowed to mate and they were fed on nympal stages of

the prey. Survival and number of eggs laid by females were recorded daily.

Data analysis

Data were analyzed using age-stage, two-sex life table theory. Therefore, developmental time of all individuals and female daily fecundity were analyzed according to the age-stage, two-sex life table theory (Chi and Liu, 1985; Chi, 1988).

The age-stage specific survivorship (s_{xj}) (where x= age and j= stage), the age-stage specific fecundity (f_{xj}), the age-specific survival rate (l_x), the age-specific fecundity (m_x), and the population parameters (r, the intrinsic rate of increase; λ, the finite rate of increase, λ= e^r; R$_0$, the net reproductive rate; T, the mean generation time) were calculated accordingly. The age-specific survivorship includes both male and female, and is calculated according to Chi and Liu (1985) as:

$$l_x = \sum_{j=1}^{k} s_{xj} \tag{1}$$

and

$$m_x = \frac{\sum_{j=1}^{k} s_{xj} f_{xj}}{\sum_{j=1}^{k} sxj} \tag{2}$$

where β is the number of stages. The intrinsic rate of increase was calculated using the iterative bisection method (Goodman, 1982).

$$\sum_{x=0}^{\infty} e^{-r(x+1)_{l_x m_x=1}} \tag{3}$$

Data analysis was done using TWOSEX-MSChart program (Chi, 2005). The TWOSEX-MSChart is available at http://140.120.197.173/Ecology/prod02.htm

(Chung Hsing University) and http://nhsbig.inhs.uiuc.edu/wes/chi.html (Illinois Natural History Survey).

Results
Age-stage, two-sex life table

There was no significant difference (P > 0.05) between development periods of immature stages of *S. montazerii* on *D. citri* feeding on two host plants (Table 1). The survival rate of eggs was the same on both host plants. Little mortality occurred in second, third, fourth larval instars and pre-pupal stages both on Thompson navel and Page tangerine. Total survivorship of the immature stages on Page tangerine (90%) and Thompson navel orange (88.57%) was not significantly different (Table 2).

Table 1 Mean developmental times (days; mean ± SE) of *Serangium montazerii* on *Dialeurodes citri* feeding on Page tangerine and Thompson navel orange.

Developmental stages	Host plants	
	Page tangerine	**Thompson navel orange**
Egg	4.72 ± 0.119a	4.22 ± 0.116a
First instar larva	2.11 ± 0.085a	2 ± 0.164a
Second instar larva	2.2 ± 0.09a	2.12 ± 0.092a
Third instar larva	2.76 ± 0.095a	2.48 ± 0.088a
Fourth instar larva	3.88 ± 0.118a	3.39 ± 0.106a
Prepupa	1.09 ± 0.052a	1.09 ± 0.051a
Pupa	4.19 ± 0.122a	4.21 ± 0.095a
Total pre-adult	20.84 ± 0.302a	19.27 ± 0.251a

Means within rows followed by the same letter are not significantly different according to the *t*-test at 5% (P = 0.05).

Table 2 Survival rate (%) of eggs, immature stages and adults of *Serangium montazerii* on *Dialeurodes citri* feeding on Page tangerine and Thompson navel orange.

Host plants	Egg	First Larval instar	Second Larval instar	Third larval instar	Fourth larval instar	Prepupa	Pupa	Female	Male
Page tangerine	100	100	92.5	87.5	85	85	80	35	45
Thompson navel orange	100	100	87.5	85	82.5	82.5	82.5	35	47.5

The mean pre-oviposition, oviposition and female and male longevity are given in Table 3. There were also no significant differences among these parameters on two host plants. The longevity of females was the same on Thompson navel orange and Page tangerine.

Fecundity of *S. montazerii* on *D. citri* feeding on Thompson navel orange and Page tangerine was also very close to each other with no significant difference (Table 3). The trend of age-specific fecundity (m_x) shows that reproduction began at the ages of 27 and 29 days on Thompson orange and Page tangerine, respectively. The highest fecundity was also observed on Thompson orange at the age of 37days and it was at the age of 40 days on page tangerine. The oviposition terminated at the ages of 64 and 67 days on Thompson orange and Page tangerine, respectively (Fig. 1). The survival rates trends of adult lady beetles were similar on both host plants (Fig. 1). Based on the age-stage, two-sex life table, the age-stage-specific life expectancy (e_{xj}) gives the expected life span of an individual of age *x* and stage *j* can live after age *x*. The trend of expected life span was similar on both host plants (Fig. 2). The reproductive value (v_{xj}) is the contribution of individuals of age *x* and stage *j* to the future population (Fig. 3). Peaks of reproductive value occurred at ages of 31 and 33 days when reared on Thompson navel orange and page tangerine, respectively.

Population growth parameters
The population parameters were calculated based on data of the entire cohort, i.e., both sexes and the variable developmental rates among individuals, Standard errors and parameter of the intrinsic rate of increase (*r*), net reproductive rate (R_0), mean generation time (*T*) and the finite rate of increase (*λ*) are shown in Table 4. There were no significant differences between these parameters on the two host plants using t-test at the 5% significance level.

Table 3 Biological parameters, longevity (days) and fecundity of *Serangium montazerii on Dialeurodes citri* feeding on Page tangerine and Thompson navel orange (mean ± SE). according to the *t*–test at 5% (*P* = 0.05).

Host plants	Preoviposition period	Ovipositional period	Female adult longevity	Male adult longevity	Fecundity (F) (eggs/female)
Page tangerine	9.93 ± 0.27[a]	29.64 ± 0.91[a]	87 ± 0.79[a]	72.61 ± 0.81 [a]	457.14 ± 11.10[a]
Thompson navel orange	9.36 ± 0.17[a]	33.36 ± 0.51[a]	85.57 ± 0.55[a]	71.84 ± 1.15[a]	528.57 ± 12.37[a]

Table 4 Associated life table estimates for population parameters (Means ± SE) of *Serangium montazerii* calculated using the age-stage, two-sex life table on Page tangerine and Thompson navel orange.

Parameters	Page tangerine	Thompson navel orange	*t*	*P*
Net reproductive rate (R_0) (offspring)	160 ± 35.12	185 ± 40.59	0.47	0.65
Intrinsic rate of increase (*r*) (day⁻¹)	0.13 ± 0.06	0.14 ± 0.08	1.00	0.33
Finite rate of increase (*λ*) (day⁻¹)	1.14 ± 0.08	1.15 ± 0.08	1.00	0.32
Mean generation time (*T*) (day)	40.57 ± 0.46	39.03 ± 0.5	-2.09	0.13
Gross reproductive rate (*GRR*) (offspring)	200 ± 41.14	224.24 ± 46.59	0.39	0.69
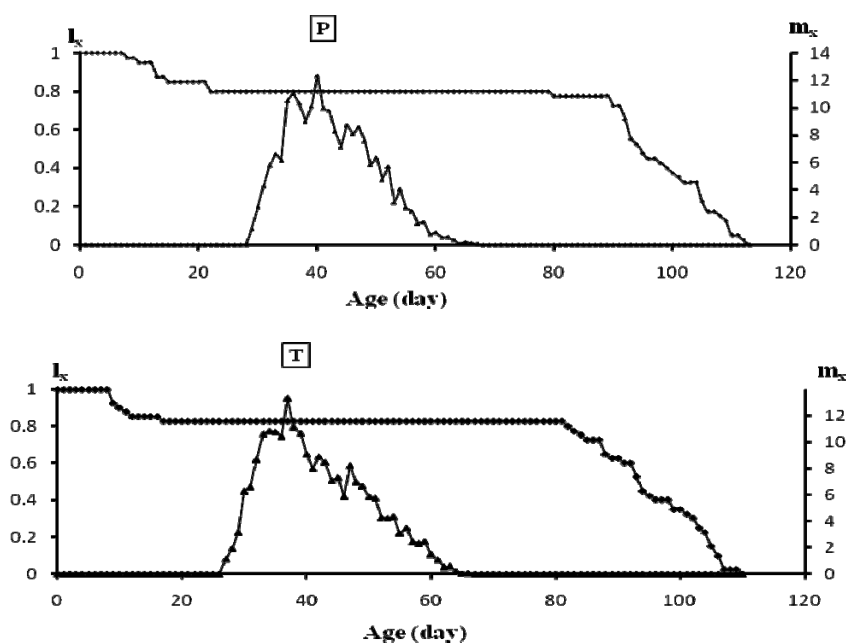
Figure 1 Age-specific survival rate (l_x) for pre-adult and adult stages, and age-specific fertility (m_x) of *Serangium montazerii* feeding on *Dialeurodes citri* feeding on Page tangerine and Thompson navel orange (P = Page tangerine, T = Thompson navel orange)
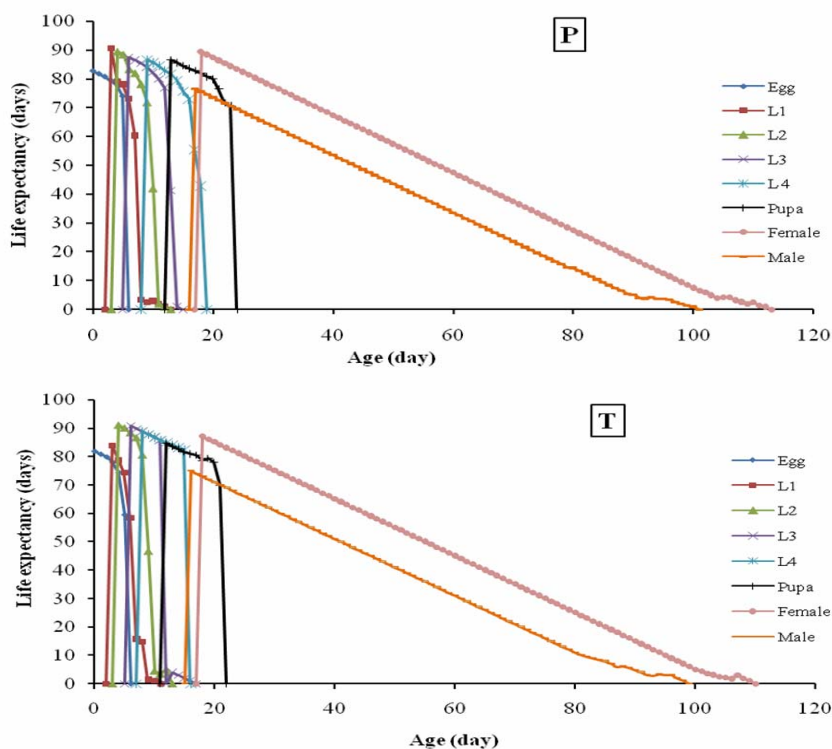
Figure 2 Age-stage-specific life expectancy of *Serangium montazerii* on *Dialeurodes citri* feeding on Page tangerine and Thompson navel orange (P = Page tangerine, T = Thompson navel orange).

55
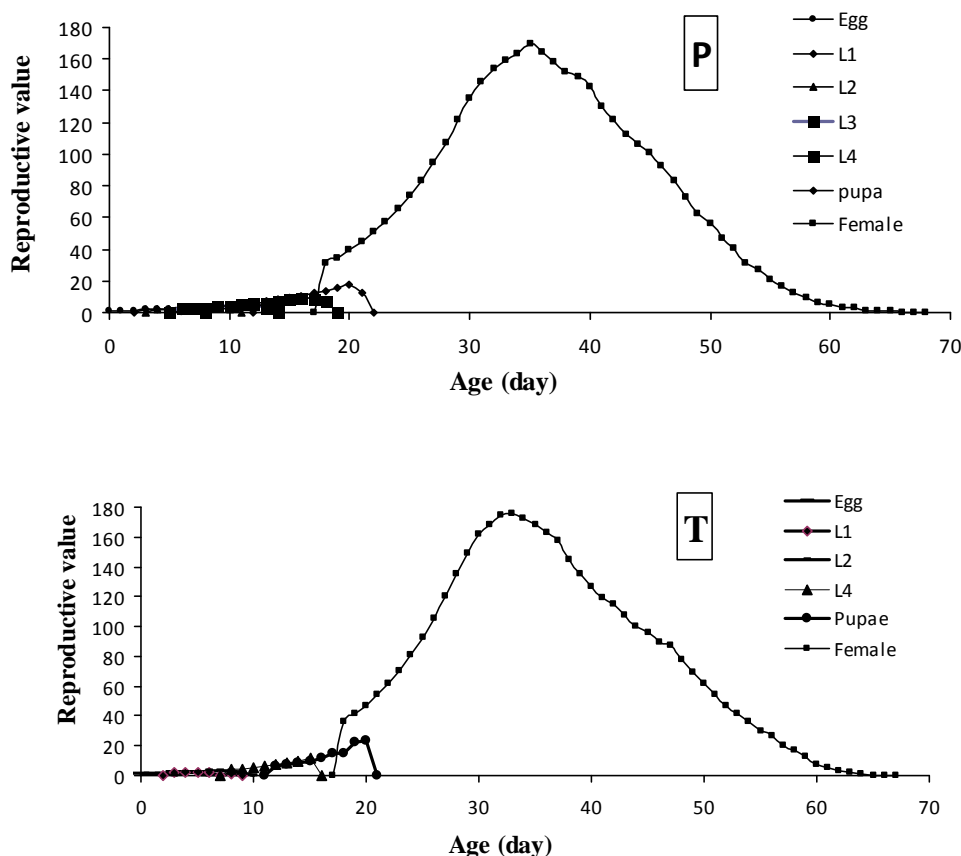
Figure 3 Age-stage-specific reproductive value of *Serangium montazerii* on *Dialeurodes citri* feeding on Page tangerine and Thompson navel orange (P = Page tangerine, T = Thomson navel orange).

Discussion

Studies have shown that development, survivorship and reproduction of ladybeetles vary significantly with host plant (LeRu and Mitsipa, 2002; Vatansever *et al*., 2003; Du *et al*., 2004; Fukunaga and Akimoto, 2007; Soroushmehr *et al*., 2008; Yao *et al*., 2010). Host plants sometimes indirectly affect the performance of natural enemies of phytophagous insects (Price *et al*., 1980; Ohgushi, 2005). For example, there is variation in the fatty acid content of the aphid, *Acyrtosiphon pisum* (Harris) depending on its host plant, and this in turn influences the performance of its insect natural enemies (Giles

et al., 2000, 2002). Fukunaga and Akimoto (2007) found that the aphid, *Aulacorthum magnoliae* Essig & Kuwana has the potential to assimilate toxic substances from its host plants as larvae of the Harlequin ladybeetle, *Harmonia axyridis* (Pallas) fed on aphids reared on elder (*Salix sieboldiana* L.) suffered significantly higher mortality and grew more slowly. Low nutritional value can also act as a defense against herbivory and decrease the herbivore's fecundity or increase its developmental time (Michaud, 1999). However, in the current study, *S. montazerii* could complete all developmental stages on *D. citri* feeding on two host plants and the host plants had no significant effect on its biological and

56

demographic parameters. Adult longevity of *S. montazerii* females was longer than males which is in agreement with Al-Zyoud (2008), for the adult longevity of *S. montazerii* females and males on cucumber at 25 °C. Mean pre-oviposition was nearly the same on both host plants at 25 °C. This was in the same range for Thompson navel orange as found by Al-Zyoud (2008).

The mean fecundity of *S. montazerii* was higher on Thompson navel orange than on Page tangerine. According to Al-Zyoud (2008) fecundity of *S. montazerii* was found to be 228 eggs on cucumber at 25 °C that was very much lower than the results obtained here. However, the total fecundity (444 eggs) of *S. parcesetosum* Sicard reported by Ahmad and Abboud (2001) on cabbage was in agreement with the mean total fecundity of the predator on Page tangerine. The prey species also affects the predator's fecundity, as *S. montazerii* fed on *T. vaporariorum* feeding on cucumber laid 28 eggs (Al-Zyoud *et al.*, 2005), which was much lower than that obtained in this study. These differences may be due to differences in host plants, prey and predator species. Peak reproductive values on the two host plants were very close to each other, it occurred only two days later on page tangerine.

The intrinsic rate of increase (*r*) is a more useful statistic to compare the population growth potential of different species than is R_0 (Price, 1997). According to Southwood (1981) and Huffaker *et al.* (1984), r-strategists are characterized by a high *r*, a large fecundity (large R_0) and short generation time (*T*). In this study, higher *r* value was obtained on Thompson navel orange (0.14 ± 0.07). However, Songlin *et al.* (2010) obtained the highest *r* value (0.739) for *S. japnicum* Chapin feeding on *Bemisia tabaci* Gennadius feeding on *Codiaeum variegatum* (L.) at 23 °C. The range of this parameter in our study is also to some extent in agreement with those of Songlin *et al.* (2010) at 26, 29 and 32°C (0.106, 0.113, 0.103 day^{-1}), respectively. The generation time for *S. montazerii* on Page tangerine and Thompson navel orange was

nearly the same. This was lower than those reported for *S. japonicum* on *Bemisia tabaci* at different temperature levels, except for 32 °C (36.6 days) (Songlin *et al.*, 2010). The finite rate of increase (*λ*) was greater than 1 on both host plants, so these results may suggest that *S. montazerii* would be considered as a r-strategist predator.

Although the life table parameters of *S. montazerii* feeding on *D. citri*, on two related host plants were very close to each other, the lady-beetle showed a slightly better reproductive performance on Thompson navel orange than on Page tangerine. However, it can be concluded that information on the life table parameters of *S. montazerii* on two different host plants provide useful information that would facilitate more effective control of *D. citri* by this predator.

Acknowledgement

References

Agrawal, A. 2000. Mechanisms, ecological consequences and agricultural implications of tri-trophic interactions. Current Opinion in Plant Biology, 3: 329-335.

Ahmad, M., and Abboud, R. 2001. A comparative study of *Serangium parcesetosum* Sicard and *Clitostethus arcuatus* (Rossi) (Col., Coccinellidae): two predators of *Bemisia tabaci* (Genn.) in Syria. Arab Journal of Plant Protection, 19: 40-44.

Al-Zyoud, F. A. 2008. Biology and potential of the Indian ladybird *Serangium montazerii* on *Bemisia tabaci*. Jordan Journal of Agricultural Sciences, 4 (1): 26-40.

Al-Zyoud, F. A., Blaeser, P., and Sengonca, C. 2005. Investigations on the biology and prey consumption of the predator, *Serangium montazerii* Fürsch (Col., Coccinellidae) by

feeding on *Trialeurodes vaporariorum* Westwood (Hom., Aleyrodidae) as prey. Journal of Plant Diseases and Protection, 112: 485-496.

Asiimwe, P., Ecaat, J. S., Guershon, M., Kyamanywa, S., Gerling, D., and Legg, J. P. 2007. Evaluation of *Serangium* n. sp. (Col., Coccinellidae), a predator of *Bemisia tabaci* (Hom., Aleyrodidae) on cassava. Journal of Applied Entomology, 131 (2): 76-80.

Bevill, T. S. Jr, and Louda, S. M. 1999. Comparison of related rare and common species in the study of plant rarity. Conservative Biology, 13: 493-498.

Birch, L. C. 1948. The intrinsic rate of natural increase of an insect population. Journal Animal Ecology, 17: 15-26.

Carey, J. R. 1993. *Applied Demography for Biologists*. Oxford University Press, New York.

Chi, H., 1988. Life-table analysis incorporating both sexes and variable development rate among individuals. Environmental Entomology, 17: 26-34.

Chi, H. 1990. Timing of control based on the stage structure of pest population: a simulation approach. Journal of Economic Entomology, 83: 1143-1150.

Chi, H. 2005. TWOSEX-MSChart: a computer program for the age-stage, two-sex. life table analysis (http://140.120.197.173/Ecology/Download/ Twosex-MSChart.zip).

Chi, H., and Liu, H. 1985. Two new methods for the study of insect population ecology. Bulletin of Institute of Zoological Academy Sinica, 24: 225-240.

Chi, H., and Getz, W. M. 1988. Mass rearing and harvesting based on an age-stage, two-sex life table: a potato tuber worm (Lep.: Gelechiidae) case study. Environmental Entomology, 17: 18-25.

Cortesero, A. M., Stapel, J. O, and Lewis, W. J. 2000. Understanding and manipulating plant attributes to enhance biological control. Biological Control, 17: 35-39.

Du, L., Ge, F., Zhu, S., and Parajulee, M. N. 2004. Effect of cotton cultivar on development and reproduction of *Aphis gossypii* (Homoptera: Aphididae) and its predator, *Propylaea japonica* (Coleoptera: Coccinellidae). Journal of Economic Entomology, 97: 1278-1283.

Fukunaga, Y., and Akimoto, S. 2007. Toxicity of the aphid *Aulacorthum magnoliae* to the predator *Harmonia axyridis* (Coleoptera: Coccinellidae) and genetic variance in the assimilation of the toxic aphids in *H. axyridis* larvae. Entomological Science,10: 45-53.

Gabre, R. M., Adham, F.K., and Chi, H., 2005. Life table of *Chrysomya megacephala* (Fabricius) (Diptera: Calliphoridae). Acta Oecology, 27: 179-183.

Giles, K. L., Madden, R. D., Payton, M. E., and Dilwith, J. W. 2000. Survival and development of *Chrysoperia rufilabris* (Neuroptera: Chrysopidae) supplied with pea aphids (Homoptera: Aphididae) reared on alfalfa and faba bean. Environmental Entomology, 29: 304-311.

Giles, K. L., Madden, R. D., Payton, M. E., and Dilwith, J. W. 2002. Host plants affect

predator fitness via the nutritional value of herbivore prey: investigation of a plant-aphid-ladybeetle system. Biocontrol, 47: 1-21.

Greathead, A. H. 1986. Host plants, In: Cock, M. J. W. [ed.], *Bemisia* tabaci- a literature survey, CAB International Institute of Biological control, Silwood Park, pp. 17-26.

Huffaker, C. B., Berryman, A. A., and Laing, J. E. 1984. In: Huffaker, C. B., Rabb, R. L. (Eds.) Natural control of insect populations. Ecological Entomology, Wiley, New York, pp. 359-398.

LeRu, B. P., and Mitsipa, A. 2002. Comparative life table statistics of *Exochomus flaviventris* reared on the cassava mealybug, *Phenacoccus manihoti*, fed on four hostplants. Insect Science Application, 22: 175-182.

Leslie, P. H. 1945. On the use of matrices in certain population mathematics. Biometry, 33: 183-212.

Letourneau, D. K. 1988. Conceptual framework of three trophic interactions. In: Barbosa, P., Letourneau, D. K. (Eds.). Novel aspects of insect-plant interactions. John Wiley & Sons, Chichester, pp. 1-9.

Lewis, E. G. 1942. On the generation and growth of a population. Sankhya, 6: 93-96.Medeiros, R. S., Ramalho, F. S., Lemos, W. P., and Zanuncio, J. C. 2000. Age-dependent fecundity and fertility life tables for *Podisus nigrispinus* (Heteroptera: Pentatomidae). Journal of Applied Entomology, 124: 319-324.

Montazeri, M. H., 1994. Fauna of lady beetles (Coccinellidae) in Dashte Gorgan and Gonbad (North of Iran). Msc., thesis, Shahid Chamran University, Ahvaz, Iran.

Montllor, C. 1991. The influence of plant chemistry on aphid feeding behavior. In: Bernays, E. A. (Ed.) Insect–Plant Interactions, CRC, Boca Raton, FL, Vol. 3, pp. 125-173.

Naranjo, S. E. 2001. Conservation and evaluation of natural enemies in IPM systems for *Bemisia tabaci*. Crop Protection, 20: 835–852.

Norris, D. M., and Kogan, M. 1980. Biochemical and morphological bases of resistance. In: Maxwell, F. C., and Jennings, P. R. (Eds.) Breeding Plants Resistant to Insects, Wiley, New York, pp. 23-61.

Ohgushi, T. 2005. Indirect interaction webs: herbivore-induced effects through trait change in plants. Annual Review of Ecology and Systematics, 36: 81-105.

Price, P. W. 1997. Insect Ecology, 3rd edn. Wiley, NewYork.

Price, P. W., Bouton, C. E., Gross, P., McPheron, B. A., Thompson, J. N., and Weis, A. E. 1980. Interaction among three trophic levels: influence of plants on interaction between insect herbivores and natural enemies. Annual Review of Ecology and Systematics, 11: 4-65.

Rapisarda, C., Mifsud, D., and Martin, J. M. 1996. Current studies on the whitefly fauna of the Mediterranean Basin (Homoptera: Aleyrodidae). Proceeding of the XXI International Congress of Entomology, Firenze 25-31 08 Summary No. 22-91.

Rutledge, C. E., and O'Neil, R. J. 2005. *Orius insidiosus* (Say) as a predator of the soybean aphid, *Aphis glycines* Matsumara. Biological Control, 33: 56-64.

Slansky, F., and Feeny, P. 1977. Stabilization of the rate of nitrogen accumulation by larvae of the cabbage butterfly on wild and cultivated food plants. Ecological Monographs, 47: 209-228.

Songlin, Y., Zhen, H., Shunxiang, R., Mandour, N., and Shaukat, A. 2010. Effects of temperature on development, survival, longevity, and fecundity of *Serangium japonicum* (Coleoptera: Coccinellidae), a predator of *Bemisia tabaci* Gennadius (Homoptera: Aleyrodidae), Biocontrol Science and Technology, 21 (1): 23-34.

Soroushmehr, Z., Sahragard, A., and Salehi, L. 2008. Comparative life table statistics for the ladybeetle, *Scymnus syriacus* reared on the green citrus aphid, *Aphis spiraecola*, fed on two host plants, Entomological Science, 11: 281-288.

Southwood, T. R. E. 1981. Bionomics strategies and population parameters. In: May, R. M. (ed.) Theoretical Ecology: Principles and Applications, 2nd edn, Blackwell, Oxford, pp 30-52.

Southwood, S. R. 1986. Plant surface and insects–an overview. In: Juniper, B., Southwood, S. R. (Eds.), Insects and the plant surface. Edward Arnold, London, UK, pp. 1-22.

Southwood, T. R. E, and Henderson, P. A. 2000. Ecological Methods, 3rd edn. Blackwell, Oxford. A Literature Survey on the Cotton Whitefly with Annotated Bibliography. CAB. International Institute of Biological Control, UK.

Uygun, N., Ohnesorge, B., and Ulusoy, R. 1990. Two species of whiteflies on citrus in Eastern Mediterranean: *Parabemisia myri-cae* (Kuwana) and *Dialeurodes citri* (Ashmead). Morphology, biology, host plants and control in Southern Turkey. Journal of Applied Entomology, 110: 471-482.

Vatansever, G., Ulusoy., M. R., and Bakirciolu, P. L. 2003. Improving the mass rearing possibilities of *Serangium montazerii* Fursch (Coleoptera: Coccinellidae) on different host plants of,*Bemesia tabaci* Genn (Homoptera: Aleyrodidae). Turkish Journal of Agriculture, 27, 175-181.

Yasnosh, V. A., and Chaidze, T. A. 1986. *Serangium* against Citrus Whitefly in IntegratedPest Control of Citrus Groves. Leaflet, Moscow, pp. 212.

Yao, S., Huang, Zh., Ren, S., Mandour, N., and Shaukat, A. 2010. Effects of temperature on development, survival, longevity, and fecundity of *Serangium japonicum* (Col.,Coccinellidae), a predator of *Bemisia*

tabaci Gennadius (Hom., Aleyrodidae). Biocontrol Science and Technology, 21 (1): 23-34.

Yigit, A., Canhilal, R., and Ekmekci, U. 2003. Seasonal population fluctuations of *Serangium montazerii* (Col., Coccinellidae), a predator of citrus whitefly, *Dialeurodes citri* (Hom., Aleyrodidae) in Turkey's Eastern Mediterranean Citrus Groves. Environmental Entomology, 32: 1105-1114.

Žaniĉ, K., Igrc Barčić, J., and Kačić, S. 2001. *Dialeurodes citri* (Ashmead, 1885) in the Adriatic Region of Croatia. Agriculturae Conspectus Scientificus, 66 (3): 161-168.

مقایسه پارامترهای دموگرافیک (Coleptera: Coccinellidae) *Serangium montazerii* روی سفید بالک مرکبات (Hemipera: Aleyrodidae) *Dialeurodes citri* با تغذیه از دو میزبان گیاهی

معصومه فتوک کیایی[1]، احد صحراگرد[1]* و محمد فاضل حلاجی ثانی[2]

۱- گروه گیاه‌پزشکی، دانشکده علوم کشاورزی، دانشگاه گیلان، رشت

۲- مؤسسه تحقیقات مرکبات کشور، استان مازندران، رامسر، ایران

* پست الکترونیکی نویسنده مسئول مکاتبه: Sahragard@guilan.ac.ir

چکیده: پارامترهای دموگرافیک کفشدوزک، *Serangium montazerii* Fursch، با تغذیه از سفید بالک مرکبات، *Dialeurodes citri* Ashmead روی دو میزبان گیاهی تعیین شد. نارنگی Page و پرتقال تامسون ناول به‌عنوان میزبان‌های گیاهی مورد استفاده قرار گرفتند. این بررسی در شرایط آزمایشگاهی (دمای۱ ± ۲۵ درجه سلسیوس و رطوبت نسبی ۵ ± ۷۰ درصد، با دوره نوری۱۶ : ۸ ساعت روشنایی به تاریکی) انجام شد. مجموع دوره پیش از بلوغ کفشدوزک روی نارنگی Page و پرتقال تامسون ناول به‌ترتیب ۰/۳۰۲ ± ۲۰/۸۴ و ۰/۲۵۱ ± ۱۹/۲۷ روز بود. نرخ بقا از تخم تا حشره کامل روی دو میزبان گیاهی خیلی به‌هم نزدیک بود. دوره تخم‌ریزی و مجموع تخم‌های گذاشته شده توسط هر ماده روی نارنگی Page و پرتقال تامسون ناول به‌ترتیب ۰/۹۰۵ ± ۲۹/۶۴، ۰/۵۹۹ ± ۳۳/۳۶ روز و ۰۹۹/۱۱±۴۵۷/۱۴، ۱۲/۳۶۹ ± ۵۲۸/۵۷ تخم بود. اوج مقادیر تولید مثل روی نارنگی Page و پرتقال تامسون ناول به‌ترتیب در روزهای ۳۱ و ۳۳ اتفاق افتاد. نرخ ذاتی افزایش جمعیت (r) روی نارنگی Page و پرتقال تامسون ناول بدون تفاوت معنی‌دار به‌ترتیب ۰/۰۶۳ ± ۰/۱۳۴ و ۰/۰۰۶ ± ۰/۱۲۶ بر روز بود. مدت زمان نسل (T) روی دو میزبان گیاهی به‌ترتیب ۰/۵ ± ۳۹/۰۳ و ۰/۴۶ ± ۴۰/۵۷ روز بود. اگرچه پارامترهای جدول زندگی S. montazerii با تغذیه از D. citri دو میزبان گیاهی وابسته خیلی به‌هم نزدیک بود ولی کفشدوزک تا حدی عملکرد تولید مثلی بهتری روی پرتقال تامسون ناول نسبت به نارنگی Page از خود نشان داد.

واژگان کلیدی: مدت زمان یک نسل، نرخ ذاتی افزایش جمعیت، پارامترهای جدول زندگی، S. montazerii، بقا