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Effect of temperature on biology and life table parameters of the jasmine whitefly, *Aleuroclava jasmini* (Takahashi) (Hemiptera: Aleyrodidae)

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Abstract

Biology and life table parameters of the jasmine whitefly, *Aleuroclava jasmini* (Takahashi) were studied at five constant temperatures (20, 25, 27, 30 and 32 °C) under laboratory conditions. Egg-to-adult developmental time of female ranged from 53.22 at 20 °C to 26.70 days at 32 °C. Immature mortality decreased from 41.77 to 16.07 % with increasing temperature from 20 to 30 °C. The threshold temperatures of egg, first, second, third and fourth nymphal stage (prepupa+ pupa) and a generation were 14.87, 9.33, 10, 14.44, 10.50 and 13 °C whereas the degree-day requirement at each stage was 105.208, 143.688, 75.95, 37.523, 134.904 and 465.61 DD, respectively. The mean total fecundity of *A. jasmine* was 18.24, 22.19, 25.53, 38.28 and 29.93 eggs at 20, 25, 27, 30 and 32 °C, respectively. Also, the mean adult longevity was 12.41, 7.35, 3.40, 2.64 and 2.12 days at the same five temperatures. The intrinsic rate of increase was 0.042, 0.061, 0.089, 0.127 and 0.114 female/ female/ day at 20, 25, 27, 30 and 32 °C, respectively. Optimal temperature for development, survival, and reproduction, within the range examined, was 30 °C.

Keywords: Aleuroclava jasmini, life history, intrinsic rate of natural increase

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Introduction

The Jasmine whitefly, *Aleuroclava jasmini* (Takahashi) is a polyphagous multivoltine pest that infests many agricultural crops, especially orange, *Citrus sinensis* (L.) in subtropical areas (Mound and Halsey, 1978; Jesudasen and David, 1990; Martin and Mound, 2007). Feeding and honeydew production by *A. jasmini* affect the quantity and quality of yield of its host plants (Rasekh, 2010; Bagheri, 2012). Outbreaks of jasmine whitefly in citrus orchards of Dezful city in Khuzestan province has caused serious damage citrus yield (Bagheri, 2012).

Ghodrati et al. (2014) studied some aspects of the biology of the Jasmine whitefly on different species of citrus and showed that *A. jasmini* had the best performance on citrus. Nymphs and adult Jasmine whiteflies suck sap mostly from the lower leaf surface. Honeydew production by later instars of *A. jasmini* and the resultant development of sooty mould reduce the yield of citrus (Bagheri, 2012) possibly by suppressing photosynthate production either by reducing light incidence to cytochrome-beating tissues or blocking stomata and thereby limiting gas exchange (Byrne et al., 1990).

Growth and development of insects is usually greatest at moderate temperatures and gradually declines at higher temperatures. Median and maximum temperatures for viability vary between species and even between developmental stages of an individual species. The reciprocal of the developmental period at constant temperature is regarded as the rate of development (Davidson, 1944), and the theoretical temperature at or below which no measurable development occurs as the threshold temperature of development. The effects of temperature on insect development and reproduction have been discussed by Andrewartha and Birch (1954), Messenger (1964) and Howe (1967) among other researchers. Presently, a paucity of information exists on biology and life table including the effect of temperature on various biological parameters of *A. jasmini* on orange tree in the literature. This study provides needed information on the life history which will be useful in planning control strategies for *A. jasmini*.

We conducted studies to determine the effect of temperature on developmental time (both stage specific and total), mortality (both stage specific and total), fecundity, longevity, sex ratio and life table parameters of *A. jasmini*. Thermal requirement of jasmine whitefly was also measured.

Materials and methods

Stock culture maintenance

Adult jasmine whitefly, *A. jasmine*, were collected using an aspirator from an orange orchard located in Safiabad Agricultural and Nature Resources Research Center, Dezful (32°22′57″N 48°24′07″E), Iran during 2013. Collected whiteflies were reared on the foliage of orange seedlings (cultivar siavaraz). Orange seedlings were planted in plastics pots (29 cm diameter, 50 cm height and 15 lit volumes). Infested seedlings were kept in a temperature-controlled cabinet at 27 ± 1°C, 60 ± 5% RH and a photoperiod of 14: 10 h (L: D).

Development and mortality

A total of 40-50 adult whiteflies of both sexes (nearly 50% male: 50% female) were placed in each clip cage attached to the underside of orange leaves (siavaraz cultivar). The clip cages were similar to those described by Lewis (1973). Experimental plants were maintained at 25 °C for 24 h for egg oviposition, and after the mentioned period, clip cages and adult whiteflies were removed. For this experiment, eight clip cages (one clip cage per leaf) were distributed on two trees. The experiment was replicated three times with total of 24 clip cages (24 leaves) on six orange trees. There were ≈ 30 eggs on each leaf, which was marked with Indian ink (Liu and Stansley, 1998). Plants were placed in germinator at five constant temperatures; 20, 25, 27, 30 and 32±1°C, 60 ± 5% RH and a photoperiod of 14: 10 h (L: D). Light intensity was set at 1800 lux. The development of immature stages was monitored with a dissecting microscope until adult emergence. The duration of immature stages and mortality were recorded daily. The numbers of male and female emerged from pupal cases were also recorded daily to determine the sex ratio.

Longevity, fecundity and life table parameters

A pair of male and female whitefly adults (less than 14 h old) was introduced into the clip cages attached to the lower surface of an orange leaf. The pair was moved to a new clip cage on a fresh leaf every 24 h until the female died. Eggs were counted daily using a 20x hand lens. Any male insect that was accidentally lost, or that died before the female, was replaced. The longevity of male and female whiteflies was also recorded.

Statistical analysis

Analysis of variance (ANOVA) and least significant difference (LSD) test were run to examine differences in developmental time, mortality, sex ratio, longevity and fecundity across temperature (SAS Institute, 1997). Data for percentage mortality and sex ratio were transformed (arcsine) before analysis.

The reciprocal of the observed developmental times, in days, provided developmental rates for each stage at each temperature. Lower developmental threshold temperature was estimated by the X-intercept method of Arnold (1959). The mean number of degree-days (DD) required for development of each life stage was calculated using the equation:

DD= D (T-t)

Where:

D= Developmental time (days)

T= Temperature (°C) during development

t= Lower developmental threshold (°C)

(Price, 1984).

Life and fertility table parameters were estimated by combining data from the preimaginal development and adult survival and reproduction experiments at different temperatures. The intrinsic rate of population increase was estimated by iteratively solving the equation by Birch (1948): $\sum e^{(-rmx)} l_x m_x = 1$.

Where x is the mean age class, m_x is the mean number of female progeny per female of age x, and l_x is the probability of survival to age x. A trial number of values for r_m were substituted into the equation until the r_m value for which the sum on the left side of the equation approximates unity. Sex ratio of the offspring of females reared at the different tested constant temperatures was estimated as described in the above-mentioned paragraph, and the results were incorporated in data analysis.

The Jacknife procedure was used to estimate as SE for the r_m values at different constant temperatures (Maia Aline et al., 2000). Further data were also calculated for each temperature: net reproduction rate of increase ($R_o=\sum l_x m_x$, number of female offspring produced per female), mean generation time (in days) ($T=ln(R_o)/r_m$), population doubling time ($DT=ln(2)/r_m$, number of days required for the population to double in numbers), finite rate of increase ($\lambda=e^{rm}$), and number of times the population will multiply itself per unit of time (Birch, 1948).

Results

The mean developmental times of *A. jasmini* at constant temperatures revealed an inverse relationship between the duration of development and temperature to which they were subjected (Table 1 and 2). Analysis of variance indicated significant differences among developmental period of the females (F=30.25; df= 4, 658; P=0.0001) and males (F=42.40; df=4, 488; P=0.0003).

The lower threshold temperatures for complete development of female and male *A. jasmini* were 13 and 14 °C, respectively (Table 3 and 4).

The mean numbers of degree-days required by *A. jasmini* females and males were 465 and 410 DD, respectively (Table 3 and 4).

Total mortality ranged from 41.7% at 20 °C to 16% at 30 C (Table 5). There were significant differences in percentage of stage-specific mortality for eggs, first instar, second instar, third instar, pupa and total mortality at the different temperatures (Table 5). In most life stages, mortality decreased from 20 to 30 °C and then increased at 32 °C (Table 5).

Sex ratio of *A. jasmini* averaged 52.32 ± 0.08, 56.38 ± 0.24, 59.45 ± 0.44, 60.10 ± 0.21 and 59.87 ± 0.15% female at 20, 25, 27, 30 and 32 °C, respectively.

An inverse relationship exists between temperature and mean adult longevity of female *A. jasmini* across the examined temperatures (Table 6). The results of ANOVA indicated that temperature was a highly significant factor affecting the longevity of both females (F=18.59; df= 4, 658; P=0.0001) and males (F=10.12; df=4, 488; P=0.0001).

Temperature had a significant effect on mean total fecundity (F=25.89; df=4, 672; P=0.0001) and mean daily fecundity (F=49.32; df=4, 672; P=0.0001). Maximum number of oviposition was recorded as 38.28 eggs at 30 °C (Table 6). At this temperature, maximum number of eggs was 15 eggs/ female/ day.

Calculated values for intrinsic rates of increase (r_m) ranged from 0.042 female/ female/ day at 20 °C to 0.127 females/ female/ day at 30 °C (Table 7). The finite rate of increase (λ) ranged from 1.072 times/ individual/ day at 20 °C to 1.562 times/ individual / day at 30 °C (Table 7). Mean generation time (T) decreased consistently with rising temperature. Least value of doubling time was estimated to be 3.688 days at 30 °C.

Table 1. Mean (± SE) developmental time (days) of *A. jasmini* females on orange (Siavaraz cultivar) at different temperatures

Stages	Temperature (°C)				
	20°C	25°C	27°C	30°C	32°C
Incubation Period	16.40 ± 0.15 a	12.58±0.08 b	8.64 ± 0.16 c	7.31 ±0.03 d	6.18 ± 0.10 e
Range (Number)	6-24.5 (102)	7-25 (106)	6.5-17 (104)	5-14 (133)	5-12 (125)
First instar nymph	12.05±0.18 a	10.20 ±0.09 b	8.05 ±0.13 c	7.01± 0.06 d	6.13± 0.05 e
Range (Number)	5-17 (80)	4.5-15 (88)	6.5-14 (98)	3.5-14 (128)	5-8 (119)
Second instar nymph	7.90 ±0.13 a	4.96 ± 0.11 b	4.07 ± 0.12 b	4.01 ± 0.08 b	3.50± 0.03 c
Range (Number)	5.5-12 (68)	3.5-11 (76)	2.5-11 (94)	2-9.5 (124)	2.5-10 (112)
Third instar nymph	5.10± 0.15 a	4.98 ±0.17 b	2.94 ±0.13c	2.09 ±0.09 c	2.12± 0.05 c
Range (Number)	4-12 (62)	3.5-9 (70)	2-7.5 (94)	2-7 (124)	2-8 (110)
Total nymphal stage	38.27 ±0.12 a	28.16 ±0.10 b	20.65 ±0.15 c	18.10 ±0.05 c	17.90 ±0.01 c
Range (Number)	4-25 (102)	3.5-25 (106)	2-17 (104)	2-14 (133)	2-12 (125)
Pupa	12.16 ±0.13a	10.63± 0.07 b	8.18±0.15 bc	7.06± 0.09 c	6.15± 0.07 c
Range (Number)	6.5-17 (59)	4.5-14 (67)	4.5-13.5 (93)	4-12 (123)	3-10.5 (107)
Total	53.22 ± 1.18 a	42.80 ± 1.24 b	31.38 ± 1.33 c	28.89 ± 1.17 d	26.70 ± 1.12 e
Range (Number)	29.5-80 (140)	27-60.5 (130)	26-39.5 (114)	20-49.5 (140)	21.5-50 (135)

Means in each row followed by the same letter were not significantly different (P> 0.05, LSD test).

Table 2. Mean (± SE) developmental time (days) of *A. jasmini* males on orange (Siavaraz cultivar) at different temperatures

Stages	Temperature (°C)				
	20°C	25°C	27°C	30°C	32°C
Egg	14.21 ± 0.17 [a]	11.10± 0.06 [b]	8.62 ± 0.14 [c]	7.20 ± 0.09 [d]	7.35± 0.05 [d]
Range (Number)	5-20 (72)	6.5-18 (73)	6.5-16 (63)	4-14.5 (83)	5-18 (78)
First instar nymph	11.85± 0.14 [a]	9.94± 0.11 [b]	8.57±0.15 [c]	6.90±0.07 [d]	6.02± 0.09 [d]
Range (Number)	3.5-18 (44)	3-17 (54)	3.5-11 (56)	4.5-12 (75)	5-18 (66)
Second instar nymph	8.85 ±0.19 [a]	4.93 ±0.17 [b]	4.70± 0.15 [b]	3.26 ±0.11 [c]	3.16± 0.07 [c]
Range (Number)	2.5-16 (31)	2.5-12 (40)	2.5-9.5 (50)	2-7.5 (69)	2-8 (58)
Third instar nymph	6.10±0.10 [a]	4.86± 0.04 [b]	3.91± 0.12 [bc]	2.23± 0.09 [c]	2.01± 0.02 [c]
Range (Number)	3.5-14 (20)	3-12 (34)	1-10.5 (49)	1-9.5 (68)	1-8.5 (54)
Total nymphal stage	38.12±0.12 [a]	28.62±0.06 [b]	22.35±0.15 [c]	18.02±0.02 [d]	17.90±0.06 [d]
Range (Number)	2.5-20 (72)	2.5-18 (73)	2.5-16 (63)	1-14.5 (83)	1-18 (78)
Pupa	11.91± 0.15 [a]	9.98±08 [b]	8.60± 0.10 [bc]	7.12± 0.07 [c]	7.05± 0.13 [c]
Range (Number)	4-15 (15)	3.5-12 (28)	1.5-12 (48)	1-10 (67)	1.5-9 (49)
Total	51.38 ± 1.48 [a]	39.56 ±1.28 [b]	31.03 ±1.01 [c]	27.12 ± 1.23 [d]	26.32 ± 1.16 [d]
Range (Number)	18.5-67 (122)	15.5-43 (100)	26-37.5 (79)	12.5-31 (95)	13.5-38 (93)

Means in each row followed by the same letter were not significantly different (*P*> 0.05, LSD test).

Table 3. Developmental rates (1/day) for immature instars regressed on constant temperatures, estimated lower developmental thresholds (t) and mean numbers of Degree-Days (DD) required for female of *A. jasmini*

Stages	Temperature (°C)				
	a	b	R^2	t (°C)	DD ± SE
Egg	0.119	0.008	0.944	14.87	105.208 ± 6.89
First instar nymph	0.056	0.006	0.940	9.33	143.688 ± 5.46
Second instar nymph	0.120	0.012	0. 951	10	75.95 ± 3.87
Third instar nymph	0.390	0.027	0.836	14.44	37.523 ± 5.97
Pupa	0.063	0.006	0.929	10.50	134.904 ± 3.65
Total	0.013	0.001	0.942	13	465.61 ± 6.86

Table 4. Developmental rates (1/day) for immature instars regressed on constant temperatures, estimated lower developmental thresholds (t) and mean numbers of Degree-Days (DD) required for male of *A. jasmini*

Stages	Temperature (°C)				
	a	b	R^2	t (°C)	DD ± SE
Egg	0.077	0.006	0.927	12.83	110.688 ± 5.874
First instar nymph	0.070	0.007	0.952	10	117.088 ± 2.85
Second instar nymph	0.244	0.017	0.968	14.35	91.35 ± 2.51
Third instar nymph	0.474	0.030	0.918	15.8	140.064 ± 6.12
Pupa	0.058	0.006	0.954	9.66	37.605 ± 1.37
Total	0.014	0.001	0.962	14	410.902 ± 3.40

Table 5. Percentage mortality (Mean± SE) of different stages of *A. jasmini* on orange (Siavaraz cultivar) at different temperatures

Stages	Temperature (°C)				
	20°C	25°C	27°C	30°C	32°C
Egg	19.50 ± 0.17[a]	13.97 ± 0.22[b]	8.01 ± 0.45[c]	6.78 ± 0.21[c]	8.33 ± 0.10[c]
Range (Number)	0-32 (88)	0-30 (51)	0-25 (26)	0-16 (19)	0-13 (25)
First instar nymph	13.81 ± 0.10[a]	11.78 ± 0.28[b]	8.11 ± 0.58[b]	4.98 ± 0.18[c]	6.54 ± 0.12[bc]
Range (Number)	0-20 (50)	0-16 (37)	0-20 (19)	0-12 (13)	0-18 (18)
Second instar nymph	8.01 ± 0.15[b]	9.38 ± 0.39[a]	7.90 ± 0.29[bc]	4.03 ± 0.19[c]	5.83 ± 0.10[c]
Range (Number)	0-15 (25)	0-15 (26)	0-15 (17)	0-11 (10)	0-15 (15)
Third instar nymph	5.92 ± 0.21[a]	4.78 ± 0.18[b]	0.50 ± 0.26[c]	0.42 ± 0.12[c]	2.47 ± 0.15[c]
Range (Number)	0-14 (17)	0-12 (12)	0-5 (1)	0-4 (1)	0-4 (6)
Pupa	2.96 ± 0.35[b]	3.76 ± 0.04[a]	2.03 ± 0.43[b]	0.84 ± 0.18[c]	3.38 ± 0.18[a]
Range (Number)	0-13 (8)	0-10 (9)	0-10 (4)	0-5 (2)	0-8 (8)
Total	41.77 ± 0.08[a]	36.98 ± 0.13[b]	25.77 ± 0.43[c]	16.07 ± 0.18[d]	24.00 ± 0.15[c]
Range (Number)	12-67 (450)	10-53 (365)	10-50 (260)	5-38 (280)	10-53 (300)

Sample size (n) in parenthesis is number dying in each stage except for total which is the initial number entering the egg stage.
Means in each row followed by the same letter were not significantly different ($P > 0.05$, LSD test).

Table 6. Longevity, daily fecundity and total fecundity (Mean ± SE) of *A. jasmini* on orange (Siavaraz cultivar) at different temperatures

Stages	Temperature (°C)				
	20°C	25°C	27°C	30°C	32°C
Female longevity	12.41 ± 0.58[a]	7.35 ± 0.05[b]	3.40 ± 0.11[c]	2.64 ± 0.07[d]	2.12 ± 0.09[d]
Range (Number)	4-18 (140)	3-10 (130)	1-7 (114)	1-4 (140)	1-4 (135)
Male longevity	7.63 ± 0.13[a]	4.80 ± 0.10[b]	2.92 ± 0.12[c]	1.30 ± 0.08[d]	1.15 ± 0.03[d]
Range (Number)	1-8 (122)	1-5 (100)	1-7 (79)	1-4 (95)	1-6 (93)
Daily fecundity	3.58 ± 0.28[d]	6.11 ± 0.15[c]	7.35 ± 0.23[bc]	10.56 ± 0.12[a]	8.43 ± 0.18[b]
Range (Number)	1-10 (140)	4-13 (130)	5-11 (114)	8-15 (154)	7-15 (135)
Total fecundity	18.24 ± 0.23[d]	22.19 ± 0.21[c]	25.53 ± 0.45[bc]	38.28 ± 0.30[a]	29.93 ± 0.27[b]
Range (Number)	6-30 (140)	6-35 (130)	8-40 (114)	11-61 (154)	8-52 (135)

Means in each row followed by the same letter were not significantly different (*P*> 0.05, LSD test).

Table 7. Life table parameters of *A. jasmini* on orange (Siavaraz cultivar) at different temperatures

Parameters	Temperature (°C)				
	20°C	25°C	27°C	30°C	32°C
Intrinsic rate of increase (r_m)	0.059 ± 0.004[c]	0.078 ± 0.003[c]	0.093 ± 0.001[b]	0.118 ± 0.002[a]	0.103 ± 0.004[a]
Net reproductive rate (R_0)	8.360 ± 0.430[c]	10.430 ± 0.410[c]	13.450 ± 0.510[b]	20.062 ± 0.430[a]	18.380 ± 0.410[ab]
Finite rate of increase (λ)	1.010 ± 0.004[c]	1.031 ± 0.003[bc]	1.097 ± 0.001[b]	1.160 ± 0.004[a]	1.125 ± 0.003[a]
Mean generation time (T)	42.820 ± 0.460[a]	29.184 ± 0.410[ab]	27.286 ± 0.221[b]	20.174 ± 0.130[c]	19.160 ± 0.420[c]
Doubling time (DT)	12.325 ± 0.156[a]	8.401 ± 0.140[ab]	7.460 ± 0.106[b]	3.508 ± 0.190[c]	4.219 ± 0.123[c]

Means in each row followed by the same letter were not significantly different (*P*> 0.05, LSD test).

Discussion

Ghodrati et al. (2014) reported the developmental time of *A. jasmini* on the same host plant and the same temperature to be 28.38 days which is shorter than our results. Mean development times from first to third nymphal instar of *A. jasmini* were usually slightly shorter than for its egg and fourth instar (prepupal and pupal) development time. Some authors have reported that the egg and fourth-instar are the longest stages for other aleyrodids (Powell and Bellows, 1992; Roermund and van Lenteren, 1992). It is of interest to know which life stages are longest when making pest management decisions, such as which biological control agents to use (e.g., egg parasitoid versus nymphal parasitoid) or which pesticide is the most appropriate (e.g., one with ovicidal versus insecticidal properties (Leddy et al., 1995).

The predicted minimum threshold of *A. jasmini* is higher than reports for other aleyrodid species. The lower threshold temperature was reported to be 11 °C for *Bemisia tabaci* Gennadius (Gerling *et al*. 1986) and 8 °C for *Trialeurodes vaporariorum* Westwood (Hulspas-Jordan and van Lenteren, 1989).

The mean number of degree-days required by *A. jasmini* female to complete its development was 465 DD which is higher than that of Osborne (1982) for *T. vaporariorum* (380 DD), Butler et al. (1983) for *B. tabaci* (320 DD calculated from their data) and that of Shishehbor and Brennan (1995) for *Trialeurodes ricini* Misra (253 DD).

Ghodrati *et al*. (2014) reported the mortaliy percentage of *A. jasmini* on the same host plant and the same temperature to be 26. 53 %, which is close to our results. Yano (1981) reported high mortality in *T. vaporariorum* at low temperatures (around 15 °C) on tobacco which compares favorably with the results obtained in the present study. Our results also agree with those of Powell and Bellows (1992) who stated that total pre-adult mortality of *B. tabaci* decreases as temperature increases (from 20 to 30 °C).

The sex ratio of *A. jasmini* recorded at different temperatures in the present study are in line with the results of Zandi Sohani et al. (2007) who reported 50, 56 and 60% female for *B. tabaci* at 20, 25 and 30°C, respectively.

Ghodrati et al. (2014) reported the longevity of *A. jasmini* female on the same host plant and the same temperature to be 3.40 days which is similar to our results. In an experiment with *Dialeurodes citri* (Ashmead), Morril and Beck (1911) found the mean longevity to be 10 days which corresponds well with the results obtained in the present study at 20 °C. However, the longevity of adult *A. jasmini* obtained in this study at different constant temperatures was shorter than those reported for other aleyrodid species. Butler et al. (1983) reported that at 26.7 and 32.2 °C, *B. tabaci* females lived 10.4 and 8.0 days and males 11.7 and 7.6 days, respectively. Powell and Bellows (1992) reported that *B. tabaci* females lived 24.6, 15.5 and 9.64 days and males 18.6, 12.23 and 7.03 days at 20, 25.5 and 29 °C, respectively. As in the present study, most researchers reported that female insects lived longer than males (Butler et al., 1983; Powell and Bellows, 1992; Fekrat and Shishehbor, 2004). Differences in species of whiteflies and host plant may account for lower longevity of *A. jasmini* in the present study.

In an experiment with *Aleurocanthus spiniferus* Quaintance, Kodama (1931) found the range of fecundity to be 17-22 eggs which is close to the results obtained in the current study. However, other laboratory studies have reported higher fecundity for other aleyrodid species. At 30 °C, Hendi et al. (1984) reported means of 203 eggs laid by *B. tabaci* on tomato. Horowitz (1983) reported that *B. tabaci* deposited a mean total number of 95.5 eggs on cotton at 30 °C. At 20, 25.5 and 29 °C, Powell and Bellows (1992) found that *B. tabaci* laid 196, 175 and 208 eggs, respectively, on cucumber. At 20, 25, 30 and 32 °C, Shishehbor and Brennan (1996) found that *T. ricini* oviposited means of 183, 224, 294 and 132 eggs, respectively.

Ghodrati *et al*. (2014) reported the r_m value of *A. jasmini* on the same host plant and the same temperature to be 0.076 female/ female/ day which is shorter than our results. In addition, Dorsman and van de Vrie (1987) reported r_m values for *T. vaporariorum* on tomato as 0.059 female/ female/ day at 15 °C and 0.121 female/ female/ day at 25 °C. Powell and Bellows (1992) reported r_m values of 0.062 and 0.169 for *B. tabaci* reared on cucumber at 20 and 30°C, respectively. Similarly, Shishehbor and Brennan (1996) reported r_m values of 0.05, 0.11, 0.18 and 0.15 at 20, 25, 30 and 35 °C, respectively. However, the values of r_m mentioned above are higher than those found in the present study at similar temperatures. Differences in the ecological factors, such as whitefly species, host plant and experimental conditions may provide an explanation for higher r_m values of other aleyrodid species in comparison to *A. jasmini*.

These data have two useful aspects. Firstly, they can be used in mass rearing programs. The optimum rearing temperature for development, survival and fecundity can be chosen from our data. Secondly, for pest management purpose, our data can be used in the construction of computer simulation models to predict *A. jasmini* development and population dynamics.

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REFERENCES

Andrewartha, H.G., and Brich, L.C. 1954. The distribution and abundance of animals. The University of Chicago Press, Chicago, Illinois.

Arnold, C.Y. 1959. The determination and significance of the base temperature in a linear heat unit system. Proceedings of American Society of Horticultural Sciences, 74: 430-445.

Bagheri, S., Kocheily, F., Mosadegh, M.S., and Shishehbor, P. 2012. Investigation on population changes of jasmine whitefly *Aleuroclava jasmini*(Takahashi) (Homo: Aleyrodidae) in citrus orchards of Dezful city. 20th Iranian Plant Protection Congress. Shiraz. page 666 (In Farsi).

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

Butler, G.D.Jr., Hennerberry, T.J., and Clayton, T.E. 1983. *Bemisia tabaci* (Homoptera: Aleyrodidae): Development, Oviposition and longevity in relation to temperature. Annals of the Entomological Society of America, 76: 310-313.

Byrne, D.N.T., Bellows, T.S.Jr., and Parrella, M.P. 1990. Whiteflies in agricultural systems. In: Gerling, D. (Ed.) Whiteflies: their bionomics, pest status and management. Intercept, Andower. pp. 227-261.

Davidson, J. 1944. On the relationship between temperature and rate of development of insects at constant temperatures. Journal of Animal Ecology, 13: 26-38.

Dorsman, R., and van de Vrie, M. 1987. Population dynamics of the greenhouse whitefly, *Trialeurodes vaporariorum* on different gerbera varieties. Bulletin of International Organization for Biological Control/ West Palearctic Regional section X, 2: 46-51.

Fekrat, L., and Shishehbor, P. 2004. Biological characteristics and life table of cotton whitefly, *Bemisia tabaci* Gennadius on aubergine at different constant temperatures. Plant Protection (Scientific Journal of Agriculture), 27: 21-32.

Gerling, D., Horowitz, A.R., and Baumgartner, J. 1986. Autoecology of *Bemisia tabaci*. Agriculture, Ecosystem and Environment, 17: 5-19.

Ghodrati, A., Shishehbor, P., and Kocheili, F. 2014. Biology and life table parameters of jasmine whitefly *Aleuroclava jasmini* on five different species of citrus. Iranian Journal of Plant Protection Science, 45(2): 213-227 (In Farsi with English abstract).

Hendi, A., Abdel-Fattah, M.I., and El-Sayed, A. 1984. Biological study on the whitefly, *Bemisiatabaci* (Homoptera: Aleyrodidae). Bulletin of Entomological Society of Egypt, 65: 101-108.

Horowitz, A.R. 1983. Population dynamics of the tobacco whitefly (*Bemisia tabaci* Gennadius) on cotton. Ph. D Thesis, Tel Aviv University.

Howe, R.W. 1967. Temperature effects on embryonic development of insects. Annual Review of Entomology, 12: 15-42.

Hulspas-Jordan, P.M., and van Lenteren, J.C. 1989. The parasite- host relationship between *Encarsia formosa* (Hymenoptera: Aphelinidae) and *Trialeurodes vaporariorum* (Homoptera: Aleyrodidae). XXX. Modelling population growth of greenhouse whitefly on tomato. Wageningen Agricultural University Papers**,** 89-2: 1-54

Jesudasen, R.W.A., and David, B.V. 1990. Revision of two whitefly genera *Aleuroclava* Singh and *Aleurotuberculatus* Takahashi (Homoptera: Aleyrodidae). FIPPAT Entomology Series, 2: 1-13.

Kodama, G. 1931. Studies on *Aleurocanthus spiniferus* Quaint. Kyushu, Japan: Kagoshima- Ken. 38 pp (In Japanese).

Leddy, P.M., Paine, T.D., and Bellows, T.S.Jr. 1995. Biology of *Siphoninus phyllyreae* (Haliday) (Homoptera: Aleyrodidae) and its relationship to temperature. Environmental Entomology, 24: 380-386.

Lewis, T. 1973. Thrips: their biology, ecology and economic importance. Academic Press, London. 349 pp.

Liu, T.X., and Stansly, P.A. 1998. Life history of *Bemisia argentifolii* (Homoptera: Aleyrodida) on *Hibiscus rosa-sinensis* (Malvaceae). Florida Entomologist, 8: 437-445.

Maia Aline, D.H., Alferedo, J.B., and Campanhola, C. 2000. Statistical influence on associated fertility life table parameters using jackknife technique: computational aspects. Journal of Economical Entomology, 93: 511- 518.

Martin, J.H., and Mound, L.A. 2007. An annotated check list of the world's whiteflies (Insecta: Hemiptera: Aleyrodidae). Zootaxa 1492.Mangolian Press. Auckland, New Zealand.

Messenger, P.S. 1964. The influence of the rhythmically fluctuating temperatures on the development and reproduction of the spotted alfalfa aphid *Theiroaphis maculata*. Journal of Economic Entomology, 57: 71-76.

Morrill, A.W., and Back, E.A. 1911. Whiteflies injurious to citrus in Florida. USDA Bureaue. Entomological Bulletin, 92: 109 pp.

Mound, L.A., and Halsey, S.H. 1978. Whiteflies of the world. British Museum (Natural History). John Wiley and Sons. Chichester, 340 pp.

Osborne, L.S. 1982. Temperature-dependent development of greenhouse whitefly and its parasite *Encarsia formosa*. Environmental Entomology, 11: 483-485.

Powell, D.A., and Bellows, T.S.Jr. 1992. Adult longevity, fertility and population growth rates for *Bemisia tabaci* (Gennadius) (Hom.: Aleyrodidae) on two host plant species. Journal of Applied Entomology, 113: 68-78.

Price, P.W. 1984. Insect ecology. Second edition. Wiley and Sons. New York, 607 pp.

Rasekh, B. 2010. Distribution, host range and natural enemies of citrus whitefly in Fars province.M.Sc. Thesis of Entomology, Islamic Azad University Science and Research Branch, Tehran. 85 pages.

Roermund, H.J.W., and van Lenteren, J.C. 1992. The parasite-host relationship between *Encarsia formosa* (Hymenoptera: Aphelinidae) and *Trialeurodes vaporariorum* (Homoptera: Aleyrodidae) XXXIV. Life history of the greenhouse whitefly, *Trialeurodes vaporariorum* as a function of host plant and temperature. Wageningen Agriculture University, 92: 1-102.

SAS Institute. 1997. SAS/STAT user guide. Version 6.9. Cary. NC.

Shishebor, P., and Brennan, P.A. 1995. Environmental effects on Pre-imaginal development and survival of the castor whitefly, *Trialeurodes ricini* Misra. Journal of Insect Science and its Application, 16(3/4): 325-331.

Shishehbor, P., and Brennan, P.A. 1996 Adult longevity, fecundity and population growth rates for *Trialeurodes ricini* Misra (Hom.: Aleyrodidae) at different constant temperatures. The Canadian Entomologist, 128: 859-863.

Yano, E. 1981. Effect of temperature on reproduction of greenhouse whitefly, *Trialeurodes vaporariorum* (Westwood). Bulletin of Vegeteble and Ornamental Crop Research Station. Japan A, 8: 143-152

ZandiSohani, N., Shishehbor, P., and Kocheili, F. 2007. Thermal effect on the biology and life tables of *Bemisia tabaci* Gennadius (Homoptera: Aleyrodidae). Pakistan Journal of Biological Sciences, 10 (22): 4057-4062.

تأثیر دما بر زیست‌شناسی و فراسنجه‌های جدول زندگی سفیدبالک یاس، *Aleuroclava jasmini* (Takahashi) (Hemiptera: Aleyrodidae)

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چکیده

در این تحقیق زیست‌شناسی و فراسنجه‌های جدول زندگی سفیدبالک یاس *Aleuroclava jasmini* (Takahashi) در پنج دمای ثابت در شرایط آزمایشگاهی (۲۰، ۲۵، ۲۷، ۳۰ و ۳۲ درجه سلسیوس) بررسی شد. میانگین طول دوره رشد پیش از بلوغ سفیدبالک یاس ماده در بازه‌ای بین ۵۳/۲۲ در دمای ۲۰ درجه سلسیوس تا ۲۶/۷۰ روز در ۳۲ درجه سلسیوس قرار داشت. میانگین مرگ و میر پیش از بلوغ با افزایش دما از ۴۱/۷۷ به ۱۶/۰۷ کاهش یافت. آستانه رشد تخم، پوره سن اول، دوم، سوم و چهارم ویک نسل به ترتیب ۱۴/۸۷، ۹/۳۳، ۱۰، ۱۴/۴۴، ۱۰/۵۰ و ۱۳ درجه سلسیوس بود در حالی‌که میانگین تعداد روز درجه مورد نیاز در هر مرحله به ترتیب ۱۰۵/۲۰۸، ۱۴۳/۶۸۸، ۷۵/۹۵، ۳۷/۵۲۳، ۱۳۴/۹۰۴ و ۴۶۵/۶۱ روز درجه بود. میانگن تعداد تخم کل سفیدبالک *A. jasmini* در دماهای ۲۰، ۲۵، ۲۷، ۳۰ و ۳۲ درجه سلسیوس به ترتیب ۱۸/۲۴، ۲۲/۱۹، ۲۵/۵۳، ۳۸/۲۸ و ۲۹/۹۳ و میانگین طول عمر در دماهای ذکر شده به ترتیب ۱۲/۴۱، ۷/۳۵، ۳/۴۰، ۲/۶۴ و ۲/۱۲ روز محاسبه شد. نرخ ذاتی افزایش جمعیت در دماهای ۲۰، ۲۵، ۲۷، ۳۰ و ۳۲ درجه سلسیوس به ترتیب ۰/۰۴۲، ۰/۰۶۱، ۰/۰۸۹، ۰/۱۲۷ و ۰/۱۱۴ ماده/ ماده/ روز به دست آمد. دمای بهینه برای رشد، بقا و تولیدمثل سفید بالک یاس در دامنه دمایی مورد مطالعه، ۳۰ درجه سلسیوس بود.

کلیدواژه‌ها: ***Aleuroclava jasmini*، *تاریخچه زندگی، نرخ ذاتی افزایش جمعیت***