EFFECT OF TEMPERATURE AND HOST PLANT ON DVELOPMENTAL TIMES AND LIFE TABLE PRARMETERS OF *TETRANYCHUS URTICAE* KOCH ON PERSIMMON TREES. (ACARI: TETRANYCHIDAE)

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Abstract

The two-spotted spider mite, *Tetranychus urticae* Koch is one of the most important pests of deciduous fruit trees in Egypt. The reproduction, survival, and life table parameters of *T. urticae* on Kostata and Hachiya Persimmon cultivars leaves were studied under laboratory conditions of 15, 20, 25 and 30 ± 2ºC, 70 ± 5% RH and a photoperiod of 16L: 8D. The shortest period of incubation, immature stages and female longevity were 3.27, 8.92 and 12.98 days, while these periods for males were 3.35, 7.8 and 11.8 days at 30ºC on Kostata persimmon variety, respectively. 30 ºC gave the maximum value of intrinsic rate of increase ($\mathbf{r_m}$) 0.243 and 0.297 individuals/♀/ day on and maximum net reproductive rate (**Ro**) 47.51 and 63.47 individuals/♀ on Kostata and Hachiya varieties, respectively. Maximum fecundity was obtained on Kostata variety at 30ºC at day 15 as 8.93 eggs/♀/day. It was concluded that the Hachiya variety was more favorable for *T. urticae* than Kostata variety resulting in the highest fecundity and reproduction at 30°C.

INTRODUCTION

Tetranychus urticae Koch is the most polyphagous species of spider mites and has been reported from over 150 host plant species of economic value. It attacks over 300 plant species in greenhouses (Zhang (2003)).

This mite causes heavy damages to persimmon orchards at Barrage District, Qaluobia Governorate in Egypt. Symptoms of *T. urticae* damage are yellowish foliage and, whitish streaks on the stems. The population growth parameters of *T. urticae* such as developmental rate, survival, reproduction and longevity vary with temperature, host phonological stage and relative humidity (Farrag 1975, Kim *et. al*. 1993, Liu and Tsai 1998 and El-Halawany 2001). Plants have main effects on demographic parameters of spider mite population dynamics. Therefore, in order to develop a successful integrated pest management (IPM) program, it is important to accurately characterize its life-history parameters on diverse host plants (Heikal *et. al.* 1996, Abdel-Wahed 2003, Ismail 2008, 2009, Riahi *et. al*. 2011).

There is the present work aimed to study the effect of temperature and host plant of Persimmon varieties under laboratory conditions.

MATERIALS AND METHODS

Mite culture

The initial population of *T. urticae* was collected from persimmon trees (*Diospyros virginiana* L., Family Ebenaceae) in Barrage District, Qaluobia Governorate. The stock culture was maintained on persimmon leaves in a rearing chamber (25 ± 2ºC, 70 ± 5% RH. and 16:8 light (L): dark (D) and kept at Plant Protection Research Institute.

Development and biology of *T. urticae* at different temperatures

Experiments were conducted on Kostata and Hachiya persimmon varieties leaf discs at 15, 20, 25 and 30 ± 2 °C, 70 ± 5% RH and 16:8 L: D photoperiod. One leaflet from the first fully expanding leaf at the top per plant of each variety was chosen. It was well washed with running water to remove any possible residuals or mites. Leaf discs of about 2.5Cm in diameter were made surrounded by tangle foot, and placed lower surface up on of moisten cotton wool in Petri dishes of 10-cm diameter and a *T. urticae* couple (male and female) was placed on each disc, for each variety. These Petri dishes were kept at four temperatures, for 24 hours to allow mating, thereafter, males were removed, while female served as a source for known-age eggs, and larvae. About 60 hatching larvae were kept singly to a leaf of each variety and left to continue their life span. Newly emerged females were copulated and left to deposit their eggs. Monitor was conducted twice daily and essential records were noted. To determine sex ratio, ten newly emerged females to which males were added placed on leaf discs and kept under the same condition of temperatures and RH. From the deposited eggs of each female, 50 eggs (25 eggs after two days and 25 eggs after one week) were left to develop second, and then males and females were counted. This was applied for different temperatures and hosts. Dishes were kept in incubators containing saturated solution of NaCl to maintain at 7 % RH according to (Winston and Bates 1960)

Life table parameters of the two-spotted spider mite

Females of *T. urticae* reached adult stage were transferred singly each to a single female on new leaf discs. Developmental period, mortality of different stages and oviposition by resultant females were recorded daily for each female. Life table parameters were estimated according to (Birch, 1948) using the Life48, BASIC Computer program (Abou-Setta *et. al.*, 1986).

Statistical analysis

The relationship between the rate of development (Y) and temperature (X) (at a specific range) can be represented by a straight line resembled with the linear equation (Y= a + bXºC), a (intercept), b (slope of temperature). The threshold temperature for development (t_0) can be estimated using the equation, as –a/b (i.e. when Y=0). The reciprocal of the slope (b) of the straight line (i.e. 1/b) is (K), which is the number of degree-days (DDUs) above (t_0) required by an animal to complete its development as physiological time (Sharpe and De Michele 1977).

RESULTS AND DISCUSSION

Developmental times

Obtained developmental times of various stages of *T. urticae* on Kostata and Hachiya persimmon varieties at four constant temperatures (i.e. 15, 20, 25 and 30 ± 2ºC), and 70 ± 5% RH are presented in Table (1). *T. urticae* females hatched after 13.83, 9.07, 5.27, and 3.27 days at 15, 20, 25 and 30ºC on Kostata persimmon variety, respectively, while males hatched after shorter periods (Table1).

Developmental durations showed that females reached maturity after 37.9 and 12.2 days at 15 and 30ºC on Kostata variety, while these values ranged between 30.1 and 11.15 days for males, respectively, on Hachiya variety. Developmental duration was shorter on Hachiya variety.

Longevity of females and males followed similar trend. Longevity was longer on Kostata variety than on Hachiya variety at four constant temperatures.

Farrage (1975) found that immature stages of *T. arabicus* lasted from 5.6 days in female and male at 27°C and 18.5 days at 13°C.The female longevity varied from 11.9 to 24.5days at 27 and 13°C respectively. Kim *et. al.* (1993) showed that, developmental periods of *Tetranychus kanzawai* Kishida, reared on flowing tea leaves, were studied at 15, 20, 25 and 30° C. The longest duration was found to be at 15°C, the shortest at 30°C. Adult female longevity was 33.3, 16.8, 15.5 and 13.4 days, respectively. Another example Liu and Tsai (1998) studied the development of *Tetranychus tumidus* Banks on Coconut palm at 6 constant temperatures (10, 15 ,20, 25,30 and 35°C), the developmental periods of immature stages ranged from 39.6 days at 15 °C to 7.4 days at 30°C. While failed to develop beyond the larval stage at 10°C. Abdel-wahed (2003) found the shortest developmental time of female and male of *T. urticae* were 8.31& 7.43 days at 30˚C when fed on Peach leaves.

Life table parameters of *T.urticae*

Results in Table (2) showed that mean generation time (T) decreased from 43.47 to 14.34 days and from 40.34 to 11.95 days at 15 and 30ºC on Kostata and Hachiya varieties, respectively. The same trend was observed for other life table parameters (Table 2). The shortest time for population density doubling (DT) 2.85 and 2.33 days at 30ºC, while the longest period was 15.4 and 11.36 days at 15ºC on Kostata and Hachiya varieties, respectively.

Temperature and variety affected the sex ratio (females/Total) of the mite. The proportion of females in offspring increased with temperature increase. The maximum values of intrinsic rate of increase ($\mathbf{r_m}$) and the finite rate of increase (**λ)** was obtained at 30 ºC (0.243 & 1.27 and 0.297 & 1.34 individuals/♀/day) on Kostata and Hachiya varieties, respectively. Minimum values were obtained at 15 ºC. The peak net reproductive rate (Ro) occurred at 30 ºC as 47.51 and 63.47 individuals/♀ on Kostata and Hachiya varieties, respectively, the lowest was at 15 ºC, also the gross reproductive rate (GRR) was highest at 30 ºC (63 and 99 eggs/♀/generation) while the lowest was at 15 ºC (17 and 20 eggs/♀/generation), respectively.

The daily age-specific survival rate of female (Lx) and age-specific fecundity rate (M_x) of *T. urticae* on Kostata variety was illustrated in Fig. (1) and on Hachiya in Fig. (2). The daily age-specific survival rate was highest at 15ºC and decreased as the temperature increased on two persimmon varieties. The maximum number of eggs produced on Kostata variety was at 30ºC (day 15: 8.93 egg/♀/day), the lowest value was obtained at 15ºC (day 44: 1.65 egg/♀/day) on Kostata variety. The highest values obtained at 30ºC (day 14: 11.02 egg/♀/day), the lowest values obtained at 15ºC (day 40: 2.96 egg/ ♀/day) on Hachiya variety, with daily egg production gradually decreased thereafter.

Heikal *et. al.* (1996) Showed that Black michen Fig variety harbored the greatest *T. urticae* (=*T. arabicus*) density followed by Conadria variety, while Doritto was the least sensitive variety. Also, found that the three fig varieties significantly differed in their susceptibility giving, the highest fecundity 104.6 eggs/♀ on Black michen, and the lowest 26.3 eggs/♀ on Dorrito.

Bounfour and Tanigoshi (2001) stated that the net reproductive rate (R_0) and the mean generation time (T) of *T. urticae* were 24.66, 80.99, 54.86 and 86.01 and 38.29, 26.48, 21.25 and 13.86 days when mite reared at 15, 20, 25 and 30 °C, respectively. Razmjou *et. al.,* (2009) reported that R_0 and T ranged between 12.57 and 30.51 and 10.66 and 11.66 days when reared *T. urticae* at 25 °C on five bean cultivars, whereas, Osman *et. al.* (2010) showed that R_0 and T of *T. urticae* were 36.98 and 16.19 at 28°C. El- Halawany (2001) found that, the high fecundity of

female (128.05 eggs/♀) was recorded at 30˚C. In addition, the highest intrinsic rate of increase (r_m) (0.29) was obtained at 30˚C when *T. urticae* fed on Black michen fig variety, and lowest fecundity 32.68 eggs/♀ and the lowest (r_m) (0.040) was obtained at 15°C on Gizi fig variety.

Abdel-wahed (2003) indicated that, the highest total mean fecundity was found at 30˚C as 149.18 eggs/♀ at highest r_m 0.24, while the longest generation was obtained at 15˚C as 38.96 days. Ismail, (2009) found the intrinsic rate of increase (rm) of *T. urticae* at 30, 25, 20, and 15 °C was 0.148, 0.160, 0.111, and 0.042 ♀/♀/day, respectively. Riahi *et al.* (2011) indicated the intrinsic rates of increase (r_m) of *T. urticae* were 0.07, 0.21 and 0.18, on three different peach varieties. Significant differences between Redtap and the other two varieties, concluding that the Redtap variety was not a suitable host as the other two varieties.

Osman *et. al.* (2012) found that, the mean generation time (T) averaged 20.259, 18.345, 14.029, 10.282 and 8.775 days. The net reproductive rate (R_o) values were 22.842, 27.024, 27.846, 22.738 and 9.790 when *T. urticae* was kept at the same temperatures. The intrinsic rate of natural increase (r_m) was 0.1543, 0.179, 0.237, 0.303 and 0.259 and the finite rate of increase (exp r_m) averaged 1.166, 1.196, 1.267, 1.355 and 1.296 at 15, 20, 25, 30 and 35°C, respectively.

Thermal requirements

Results of applying the linear model to the relation between temperature and rate of development in insects and mites is usually calculated as linear (Sharpe and De Michele, 1977). Table (3) indicated that, $\mathbf{R^2}$ values of *T. urticae* ranged between 0.93 and 0.99 of egg, larva, Protonymph, Deutonymph, generation and life span on Kostata and Hachiya persimmon varieties, respectively. Using the equation resulted in determination of lower thresholds **(t_0)** as 11.63 & 11.17, 5.55 & 7.64, 5.35 & 6.63, 8.32 & 9.49, 7.93 & 9.25 and 3.8 & 5.57°C. The thermal constant **(K)** was 64.10 & 68.02, 78.12 & 56.49, 71.42 & 61.34, 54.34 & 41.49, 312.5 & 256.4 and 666.6 & 526.3 DDs for the two previous Persimmon varieties as physiological times required for this species phenomena.

The simple linear regression between temperature (X) and developmental rate (Y) of *T. urticae* (fig.3), the regression equation of egg, larva, protonymph, deutonymph, generation and life span were Y= 0.0156x -0.1815, Y= 0.0128x -0.0711, Y= 0.014x -0.075, Y=0.0184x -0.1531, Y=0.0032x -0.0254 and Y=0.0015x -0.0057 on Kostata variety, respectively. In addition, the regression equation on Hachiya variety was near to the previous values.

These results agreed with those of Al-Sweedy (2003) who reared *Oligonychus afrasiaticus* (McGregor) at 15, 20, 25, 30 and 35°C on date palm. The thermal

constant **(K)** for egg, larva, protonymph, deutonymph and life cycle was 63.34, 49.72, 29.29, 32.8 and 172.17 DDus, respectively, the lower thresholds **(t_0)** as 12.32, 11, 14.76, 14.43 and 13 °C, respectively. Ismail (2009) studied the biology of *Panonychus citri* (McGregor) on sweet orange leaves were determined at 15, 20, 25, 30 and 35 ± 1 °C, 65 ±10% RH, the development threshold for female eggs and immature stages was 9.22 °C and 9.77 °C, respectively, while total effective temperature was 100 and 192.30 degree-days, respectively.

Osman *et. al.* (2012) studied R^2 values of larva, protonymph, deutonymph, total immatures and life cycle of *T. urticae* on caster bean as well as were 0.9102, 0.9232, 0.9013, 0.9388 0.96, regression equations.

As a result, it was noted that thermal factor had negative relationship with duration of each stage as increasing temperature rapped development and shortened, generation and life span of *T. urticae*.

Table 1. Mean developmental times in days of *T. urticae* females and males reared on Kostata and Hachiya persimmon varieties at constant temperatures and 70± 5% RH.

Parameter	sex	Kostata				Hachiya			
		15°C	20°C	25°C	30°C	15°C	20°C	25°C	30°C
Egg	♀	13.83	9.07	5.27	3.27	13.73	9.3	5.12	3.47
	♂	13.15	8.7	5.05	3.35	13.5	9	5	3.4
Larva	♀	9.27	5.2	3.65	3.4	8.62	4.25	3.2	2.6
	♂	8.55	4.45	3.45	2.95	8.05	4.15	2.5	2.15
Protonymph	♀	7.32	5.27	3.35	3	6.85	4.5	3.85	2.47
	♂	6.85	4.7	2.95	2.6	6.55	4.45	2.6	2
Deutonymph	♀	7.47	5.25	3.12	2.52	6.87	4.4	2.62	2.02
	♂	6.65	4.65	3.05	2.25	6.6	4.3	2.1	1.7
Immature stages	♀	24.08	15.73	10.13	8.92	22.35	13.15	9.67	7.1
	♂	22.05	13.8	9.45	7.8	21.2	12.9	7.2	5.85
Life cycle	♀	37.9	24.8	15.4	12.2	36.08	22.45	14.8	10.58
	♂	30.1	22.5	14.5	11.15	34.7	21.9	12.2	9.25
Longevity	♀	20.58	16.23	15.45	12.98	18.58	15.35	13.6	10.85
	♂	19.8	14.45	12.7	11.8	17.8	13.2	10.55	9.3
Life span	♀	58.48	41.03	30.85	25.18	54.65	37.8	28.4	21.43
	♂	49.9	36.95	27.2	22.95	52.5	35.1	22.75	18.55

Table 2. Life table parameters of T. urticae under different temperatures.

Parameter	Kostata				Hachiya			
	15°C	20°C	25°C	30°C	15°C	20°C	25°C	30°C
Generation time (T) [a]	43.47	27.13	17.71	14.34	40.34	24.53	16.29	11.95
Preoviposition period [a]	5.57	2.4	2.27	2.1	4.27	2.05	1.5	1.35
Oviposition period [a]	13.35	11.55	11.23	9.2	12.58	11.23	10.43	8
Mean total fecundity (egg/♀)	26.55	42.55	69.1	78.6	38.8	56.6	79.7	96
Daily rate (egg/♀/day)	2.04	3.77	6.32	8.81	3.15	5.13	8.02	12.62
Mean generation time (T_c) [a]	44.24	30.03	19.97	15.85	41.86	27.28	18.96	13.94
Doubling time (DT) [a]	15.40	7.78	3.91	2.85	11.36	6.02	3.41	2.33
Net reproductive rate (R_o) [b]	7.38	14.97	34.34	47.51	13.36	23.34	47.22	63.47
Intrinsic rate of increase (r_m) [c]	0.045	0.089	0.177	0.243	0.061	0.115	0.203	0.297
Finite rate of increase (λ)	1.04	1.09	1.19	1.27	1.06	1.12	1.22	1.34
Sex ratio (♀/total)	0.55	0.68	0.71	0.77	0.65	0.75	0.79	0.76
50% mortality [a]	37.40	33.0	25.0	20.0	45.58	31.0	23.0	18.0
Gross reproduction rate (GRR)	17	34	57	63	28	47	76	99

[a] Days [b] per generation [c] Individuals/female/ day

Table 3. Linear regression analysis values for the effect of temperature on T. urticae developmental rate.

stage	Variety	a	b	t_0	K	R^2
Egg	Kostata	-0.1815	0.0156	11.63	64.10	0.95
	Hachiya	-0.1643	0.0147	11.17	68.02	0.99
Larva	Kostata	-0.0711	0.0128	5.55	78.12	0.94
	Hachiya	-0.1353	0.0177	7.64	56.49	0.98
Protonymph	Kostata	-0.075	0.014	5.35	71.42	0.96
	Hachiya	-0.1082	0.0163	6.63	61.34	0.93
Deutonymph	Kostata	-0.1531	0.0184	8.32	54.34	0.97
	Hachiya	-0.2289	0.0241	9.49	41.49	0.98
Generation	Kostata	-0.0254	0.0032	7.93	312.5	0.99
	Hachiya	-0.0361	0.0039	9.25	256.4	0.99
Life span	Kostata	-0.0057	0.0015	3.8	666.6	0.99
	Hachiya	-0.0106	0.0019	5.57	526.3	0.99

a = Intercept, b = slope of temperature, t0 = (-a/b) K= DDUs (1/b)

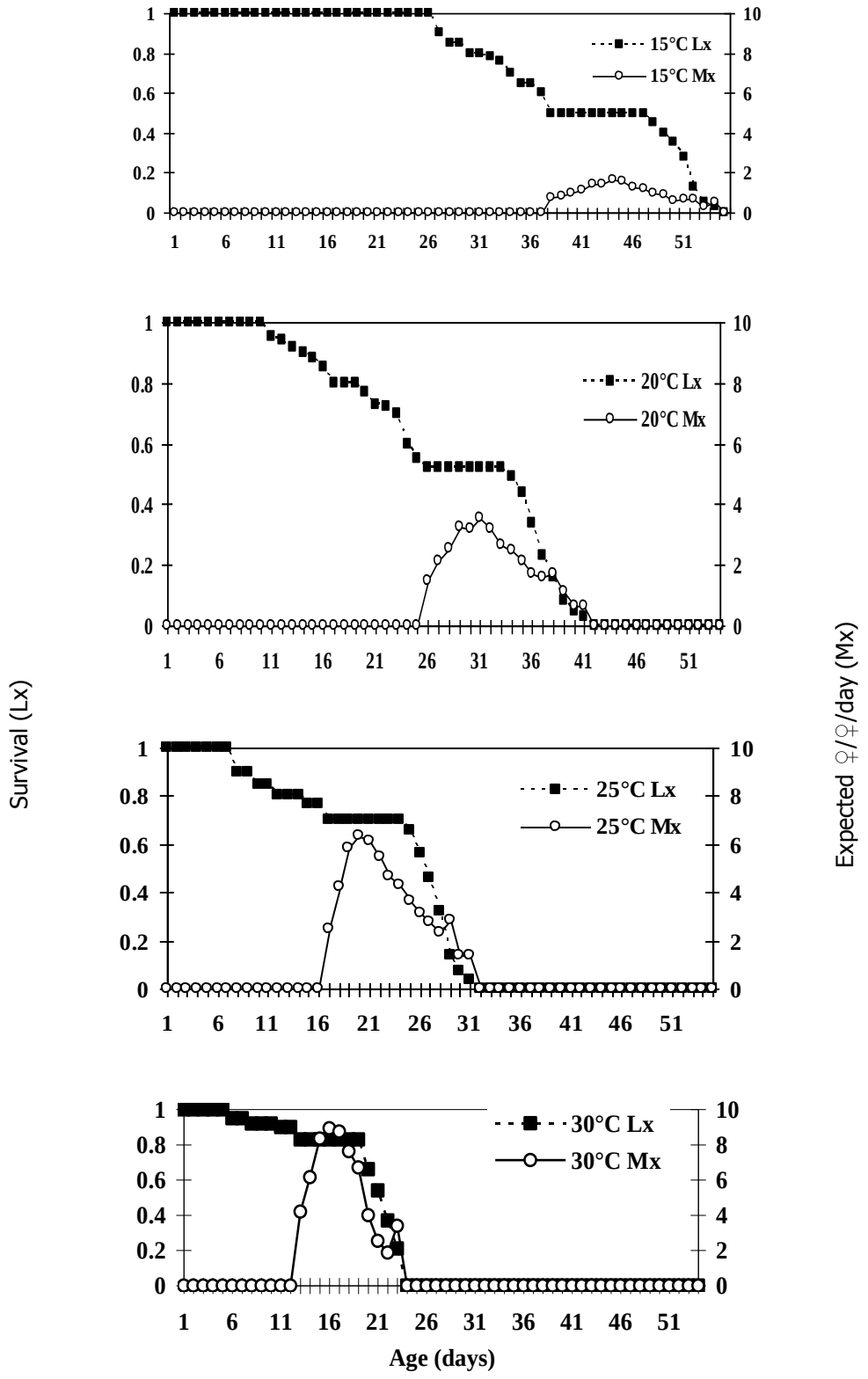

Fig. 1. Survival rate (Lx) and Age-specific rate fecundity (Mx) in *T. urticae* at different temperatures on Kostata Persimmon variety

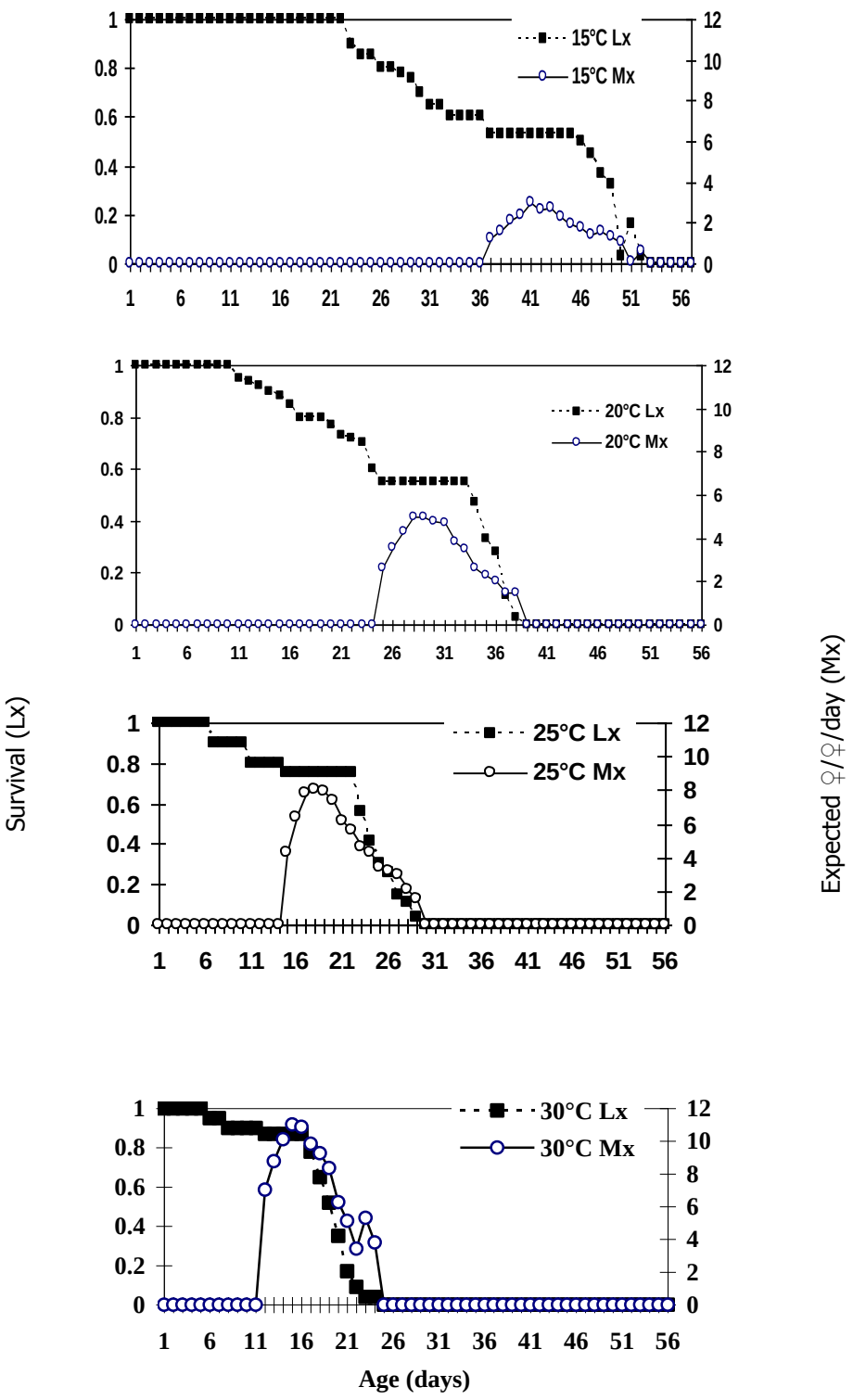

Fig. 2. Survival rate (Lx) and Age-specific rate fecundity (Mx) in *T. urticae* at different temperatures on Hachiya Persimmon variety.

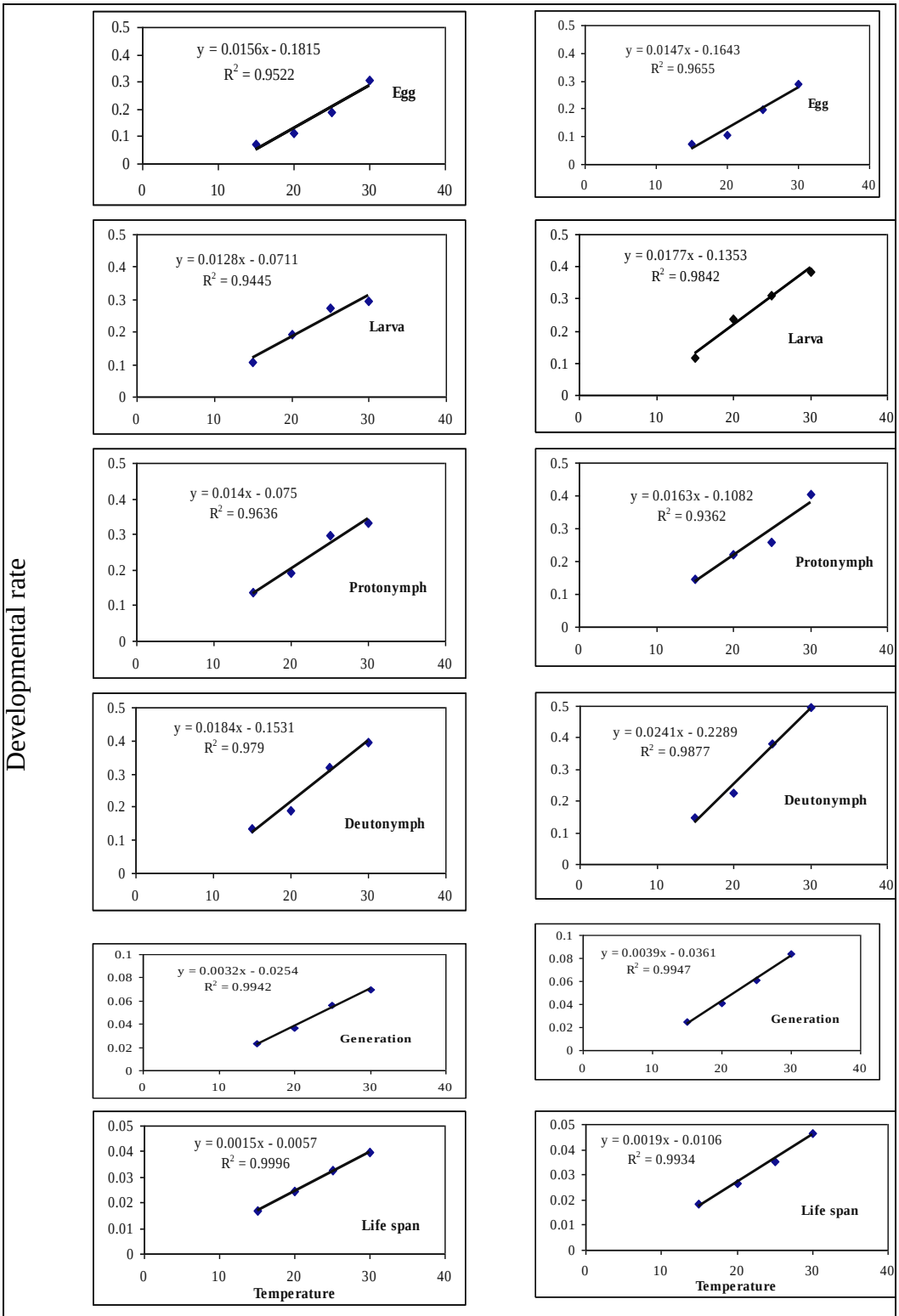

Fig. 3. Linear regression analysis values for the effect of temperature on T. urticae developmental rate.

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تأثير درجة الحرارة والعائل النباتي على فترة التطور وجداول الحياة للعنكبوت الأحمر العادي على أشجار الكاكى

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- يعتبر العنكبوت الأحمر ذو البقعتين أحد أهم الآفات التي تصيب أشجار الفاكهة المتساقطة في مصر، لذلك تم دراسة معدل البقاء والتكاثر وجدول الحياة للعنكبوت الأحمر العادي على أشجار الكاكى صنفي (هشيا وكوستاتا) معملياً على أربعه درجات حرارة (15، 20، 25، 30 ± 2°م) ورطوبة نسبية 70 ± 5%) وفترة إضاءة 16 ساعة.
- سجلت أقصر فترة لحضانة البيض وفترة الأطور غير الكاملة وفترة حياة الطور الكامل للإناث 3.27، 8.92، 12.98يوماً وللذكور 3.35، 7.8، 11.8 يوماً على درجة حرارة 30°م على صنف كوستاتا على التوالي.
- كان أعلى معدل للزيادة الطبيعي (rm) على درجة حرارة 30°م (0.243، 0.297 فرد/أنثى/ يوم) على صنفي هشيا وكوستاتا على التوالي.
- كان أعلى معدل وضع البيض على صنف كوستاتا على درجة حرارة 30°م في اليوم الخامس عشر بمعدل 8.93 بيضة/ أنثى)، وكان أقل معدل على درجة حرارة 15°م في اليوم الرابع وأربعين بمعدل (1.65 بيضة/ أنثى) على صنف كوستاتا.
- نستنتج مما سبق أن صنف هشيا هو الأكثر قابلية للإصابة بالعنكبوت الأحمر العادي من صنف كوستاتا، وأن أعلى خصوبة وكمية وضع بيض كانت على درجة 30°م.