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Temperature Effects on Some Life Table Parameters of *Tetranychus urticae* Koch (Acari: Tetranychidae)

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Abstract

Some life table statistics of the two spotted spider mite, *T. urticae* was evaluated under constant temperatures of 25º and 30ºC. Development and reproductive potential of the mite was also studied. The development time of the immature stages was 11.85±0.31 days at 25º and 8.84±0.24 days at 30ºC. The calculated time needed for the development decreased with the increase in temperature. The longest period was recorded at 25ºC but the shortest was revealed at 30ºC. The calculated developmental threshold (t_0) of the whole immature stages was estimated as 10.32ºC. The thermal units needed for the development from egg to adult were 173.97 day-degrees. The generation time (GT) was 18.31 and 12.19 days, reproductive potential (R_0) was 51.47 and 28.50 individuals / female, population doubling time (DT) was 3.22 and 2.52 days, intrinsic (r_m) was 0.2152 and 0.2748 and finite rate of increase (λ) was 1.2401 and 1.3163 at 25 and 30ºC, respectively. Based on the obtained data, temperature of 25°C was the most suitable temperature for the development and reproduction of spider mite.

Keywords: *Tetranychus urticae, development, temperatures, life table parameters.*

Introduction

The two-spotted spider mite, *Tetranychus urticae* Koch, (Acari: Tetranychidae) is an important pest of a variety of agricultural crops (Jeppson *et al.*, 1975, Karimi *et al.,* 2006, Sedaratian *et al.,* 2009 and Saeidi *et al.*, 2010). Adults and immatures feed primarily on leaves producing tiny gray or silvery spots known as stippling damage. Damage to the leaves inhibits photosynthesis, and severe infestations can result in premature leaf fall, shoot dieback, and decreased plant vigor (Zhang, 2003).

Temperature is usually the environmental factor with the greatest effect on developmental rate of immature mites. To quantify the effect of temperature on mite development, life stages of a species may be held at constant temperatures and the resultant development times can be used to estimate developmental rate curves (Southwood, 1978). Several studies have investigated the effects of temperature on development and reproduction of tetranychid mites, such as *T. urticae* on cotton (Carey and Bradley, 1982), *Tetranychus piercei* McGregor on banana (Yueguan *et al.*, 2002), *Tetranychus truncates* Ehara on mulberry (Sakunwarin *et al.*, 2003),

The objective of the present study is to evaluate the effect of constant temperatures on some biological aspects of the *T. urticae* inhabiting cucumber leaves.

Materials and Methods

The present investigation was carried out to determine the effect of constant temperatures of 25º and 30ºC on the development of the pre-imaginal developmental stages of *T. urtucae* as well as on the adult.

Rearing technique:

Specimens of *T. urticae* were colected from cucumber leaves *Cucasum sativa* L. at a field located in the farm of the Faculty of Agriculture of Assiut University. The individuals of *T. urticae* were reared in the laboratory on fresh leaves of cucumber plants under laboratory conditions. The cucumber leaves were replaced every two days by new ones. After several generations, the mites from the stock colony were used for the experiments.

Individuals of 20 mated females were transferred to cucumber leaf discs (2×5cm diameter) placed on acotton bed in Petri dishes (10cm diameters) and were allowed to lay eggs. The cotton bed was kept wet by soaking with water twice daily so that the discs remained fresh.

1- Effect of temperature on pre-imaginal development:

1.1- Egg stage:

Eggs were transferred to the leaf disc (2×2 cm), and kept under two temperatures regimes of 25ºC and 30ºC and 65±5% R.H. The rearing eggs were checked twice daily. A number of 100 eggs in four replicates were exposed to each temperature and the incubation periods as well as hatchability were recorded.

1.2- Larval stage:

Larvae (< 24 hrs old) were distributed individually in Pitri-dishes provided with cucumber leaves. About 100 larvae in four replicates were individually reared at each temperatures regime. Larvae were checked and the plant leaves were changed daily up to deutonymphal stage. The time required for the development of the larval stage was recorded.

1.3- Protonymphal stage:

Protonymph (< 24 hrs old) were also distributed individually in Pitri-dishes provided with cucumber leaves. One hundred larvae in five replicates were exposed to each temperature regime. Leaves were checked daily up to deutonymphal stage. The time required for the development of this stage was recorded.

1.4- Deutonymphal stage:

One hundred protonymphs (less than 12 hrs old) in five replicates were exposed to each temperature regime. The deutonymphs were observed daily until the adults emerged.

2- Adult stage:

Newly emerged females were copulated and left to deposit their eggs. Fifty pairs of adults were reared at each temperature and inspected daily to record the number of eggs for each female and the longevity.

Time required for the development and survival of each stage were calculated. Data were subjected to statistical analysis using t-test and means were compared according to Duncan's multiple range test.

Developmental thresholds (t_0) and thermal units (Day-degrees) required for the development of the immature stages of the mite were calculated according to Mangat (1977).

The obtained data were also used to estimate some life table parameters according to Birch (1948).

Net reproductive rate (R_0), Generation time (GT), Population doubling time (DT), Intrinsic rate of natural increase (r_m) and Finite rate of increase (λ). The definition of the abbreviations were presented by Birch (1948).

Results and Discussion

The present investigations were oriented to study the effect of constant temperature regimes of 25º and 30ºC on the development of the immature stages of *T. urticae* to estimate the developmental threshold (t_0) and thermal units (day-degrees) needed for the development of the immature stages as well as the adult reproductive potential of the red spider mite, *T. urticae*.

1- Immature stages:

1.1- Egg stage:

Data in Table 1 show that the incubation period of the mite lasted 4.00±0.00 and 2.38±0.49 days at the constant temperatures of 25º and 30ºC, respectively. There was a significant difference between the incubation periods at the tested temperatures. It was 4 days at 25ºC and 2.38 days at 30ºC.

1.2- Larval stage:

The results in Table 1 show that the durations of larval stage of *T. urticae* were 3.26±0.44 and 2.00±0.00 days at 25º and 30ºC, respectively. There was a significant difference between durations at the tested temperatures.

1.3- Protonymphal stage:

The duration of the protonymphal stage in Table 1 reveal that the protonymphal stage lasted 2.11±0.31 and 2.00±00 days at 25º and 30ºC, respectively. Statistical analysis of the data showed a significant difference between the duration of the protonymphal stage at the tested temperatures.

1.4- Deutonymphal stage:

The duration of the deutonymphal stage as shown in Table 1 show that the deutonymphal stage lasted 2.48±0.52 and 2.46±0.50 days at 25º and 30ºC, respectively. No significant differences between the duration of this stage at the tested temperatures.

2- From Egg to Adult emergence

As shown in Table 1, the longest time required for the mite to complete its life cycle was 11.85±0.31 days at 25ºC and it reached 8.84±0.24 days at 30ºC.

From the obtained results it could be revealed that immature development time of *T. urticae* were 11.85 and 8.84 days at 25º and 30ºC, respectively. Our findings are close to those found by Ahmadi *et al*., 2007. Data in Table 1 was used to calculate developmental threshold from egg to adult of the pest using hypothetical temperature thresholds below rearing temperatures of 25º and 30ºC (Table 2 and Figure 1). The calculated developmental threshold is 10.32ºC. On the base of this value, an average of 173.97 day-degrees is needed for the development of one generation of the red spider mite, *T. urticae*.

The developmental time reported by Sedaratian *et al*. (2009) on different soybean genotypes varied from 7.6 to 8.8 days for female and from 7.1 to 8.4 days for male, which is closed to the obtained results in the present study. At 30°C, our findings are in general agreement with those found in previous studies (Inglinski and Rainwater, 1954; Kasap, 2004; Parslika and Huszar, 2004; Forghani *et al*., 2006). Host plants, experimental conditions, as well as mite strain may provide an explanation for longer or lower developmental times. The mean number of degree-days required by *T. urticae* to complete its development was 160.2DD for females and 174.8 DD for males, which are higher than those estimated by Ju *et al*. (2008) on eggplant (80.5 and 74.7 DD for females and males, respectively); but lower than that reported by Kasap (2004) for female of *T. urticae* (172.4 DD) on apple. These differences may be explained by the existence of three genetically distinct host races of *T. urticae* on peach, eggplant and apple.

3- Adult stage:

3.1- Longevity:

Data in Table 3 show that the females start to lay eggs after being mated, shortly after adult emergence. The pre-oviposition period seems to be least affected by prevailing temperatures. At the tested temperatures of 25º and 30ºC means of 0.45±0.61 and 0.20±0.4 days were recorded for the pre-oviposition period, respectively. Oviposition period was 5.40±1.95 days at 30ºC whereas it was 10.45±2.25 days at 25ºC. The post-oviposition period ranged from 1.18±1.32 days at 25º to 1.40±0.97 days at 30ºC. Regardless of temperature, the pre-oviposition period needed 3.36% and the oviposition period needed 62.73%, whereas the post-oviposition period needed 23.91% of the total lifespan.

According to the longevity (male and females), as shown in Table 3, the longest period was 10.64±4.34 days for males and 12.09±2.43 days for females at 25ºC, while the shortest period was 7.00±1.76 days for males and 7.00±1.76 days for females at 30ºC. It seems that the adult females tended to live longer than males under all tested temperatures.

3.2- Egg laying capacity (fecundity):

As shown in Table 3, the maximum number of eggs (79.18±20.53 eggs / female) was recorded at 25ºC.

Longevity of *T. urticae* determined in the present study is in general agreement with that previously recorded by several investigators. Carey and Bradley (1982) found that the mean longevity of females was 14.71 and 9.71 days at 23.8º and 29.4°C, respectively. Kasap (2004) reported the longevity of females to be 29.9, 25.9, 16.8 and 4.7 days at 20º, 25º, 30º and 35°C, respectively. Rajakumar *et al*. (2005) revealed that at 25°C female and male of *T. urticea* lived for 18.7 and 12.1 days, respectively. Forghani *et al.* (2006) found that at 28ºC females and males lived for 20.8 and 19.2 days, respectively. The scatter in development values among studies can be attributed to the effects of multiple factors, including: disparities in host plant suitability, the source of *T. urticae* stock colony, discrepancy in humidity and photoperiod conditions, in addition to the frequently of checking. In the present study, at 25°C, the mean total number of eggs laid by *T. urticae* was substantially lower than egg numbers recorded on different crops in several previous studies (Shih *et al.*, 1976; Parslika and Huszar, 2004; Rajakumar *et al*., 2005; Karimi *et al*., 2006; Ju *et al*., 2008; Razmjou *et al*., 2009; Sedaratian *et al*., 2009; and Saeidi, 2011).

The calculated life table parameters at 25º and 30ºC, respectively, taken into consideration of the mite were:

Data in Table 4 show that the duration of one generation (GT) of lasted 18.31 and 12.19 days. The population of this pest had the capacity to double (DT) every 3.22, and 2.52 days. Net reproductive rate (R_0) was 51.47 and 28.50 times within a single generation. The values of intrinsic rate of increase (r_m), which express the relationships between fecundity, generation time and survival, was 0.2748 at 30º and 0.2152 at 25ºC. If r_m is a measure of the suitability of the environment, then the maximum r_m values the most appropriate reproductive potential under those conditions. Examination of the data indicates that a constant temperature of 30ºC is the optimum temperature, as it had the maximum r_m value. On the other hand, when the values of r_m were converted to the finite rate of increase (λ), it was clear that the population of *T. urticae* had a capacity to multiply about 1.2401 and 1.3163 times per female per day at 25 and 30ºC, respectively.

The present study indicates that temperature is a substantial factor affecting the reproduction and survival of *T. urticae*. Our results can be used in mass-rearing projects, and in the construction of computer simulation models to predict *T. urticae* development and population dynamics and to obtain practical information for controlling this mite, however, field studies should be undertaken to complement laboratory studies.

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تاثير درجات الحرارة على بعض مقاييس جداول الحياة لأكاروس العنكبوت الأحمر

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الملخص

أجريت هذه الدراسة بهدف معرفة تأثير درجات الحرارة الثابتة ٢٥° ، ٣٠°م على بعض مقاييس جداول الحياة لأكاروس العنكبوت الأحمر. تمت دراسة معدلات النمو والإعاشة والاقتدار التناسلي لهذه الآفة تحت نفس الظروف من الحرارة الثابتة. اتضح من الدراسة أن الوقت اللازم للنمو يقل مع زيادة درجات الحرارة. تم تسجيل أطول فترة (١١,٨٥ يوما) لنمو اكاروس العنكبوت الأحمر وهى درجة حرارة ٢٥°م في حين كانت اقصر فترة (٨,٨٤ يوما) نمو على درجة حرارة ٣٠°م. تم حساب الحد الحرج للنمو (t_0) لفترة الأطوار غير الكاملة مجتمعة ووجد انه ١٠,٣٢°م. وجد أن الوحدات الحرارية اللازمة للنمو منذ فترة طور البيضة حتى طور الحيوان الكامل هى ١٧٣,٩٧ وحدة حرارية يومية. وقد تم حساب بعض مقاييس جداول الحياة لهذه الآفة تحت نفس الظروف من الحرارة ، والمقاييس التي أخذت في الاعتبار هي: طول فترة الجيل (GT) ، معدل التضاعف (R_0) ، والزمن اللازم لتضاعف التعداد (DT)، بالإضافة إلى معدلات الزيادة (r_m) ، (λ). أوضحت القيم المحسوبة أن درجة حرارة ٢٥°م تعتبر درجة حرارة مفضلة لنمو وتكاثر أكاروس العنكبوت الأحمر.

Table 1. Duration (days) of the immature stages of *T. urticae* reared at constant temperatures of 25º and 30ºC.

Temp. (ºC)	Duration (in days) ±SE				
	Egg	Larvae	Protonymph	Deutonymph	Total
25	4.00±0.00a	3.26±0.44a	2.11±0.31a	2.48±0.52a	11.85±0.31a
30	2.38±0.49b	2.00±0.00b	2.00±0.00b	2.46±0.50a	8.84±0.24b

Means followed by the same letters vertically are not significantly different at 0.05 level of probability.

Table 2. Number of day degrees (TU) required for the development from egg to adult of *T. urticae* using hypothetical temperature thresholds below rearing temperatures of 25º and 30ºC.

Temperature thresholds (t_o)	Day degrees (TU)	
	25º (11.85)	30º (8.84)
5	237.00	221.00
6	225.15	212.16
7	213.30	203.32
8	201.45	194.48
9	189.60	185.64
10	177.75	176.80
11	165.90	167.96
12	154.05	159.12
13	142.20	150.28
14	130.35	141.44
15	118.50	132.60
16	106.65	123.76
17	94.80	114.92
18	82.95	106.08
19	71.10	97.24
20	59.25	88.40

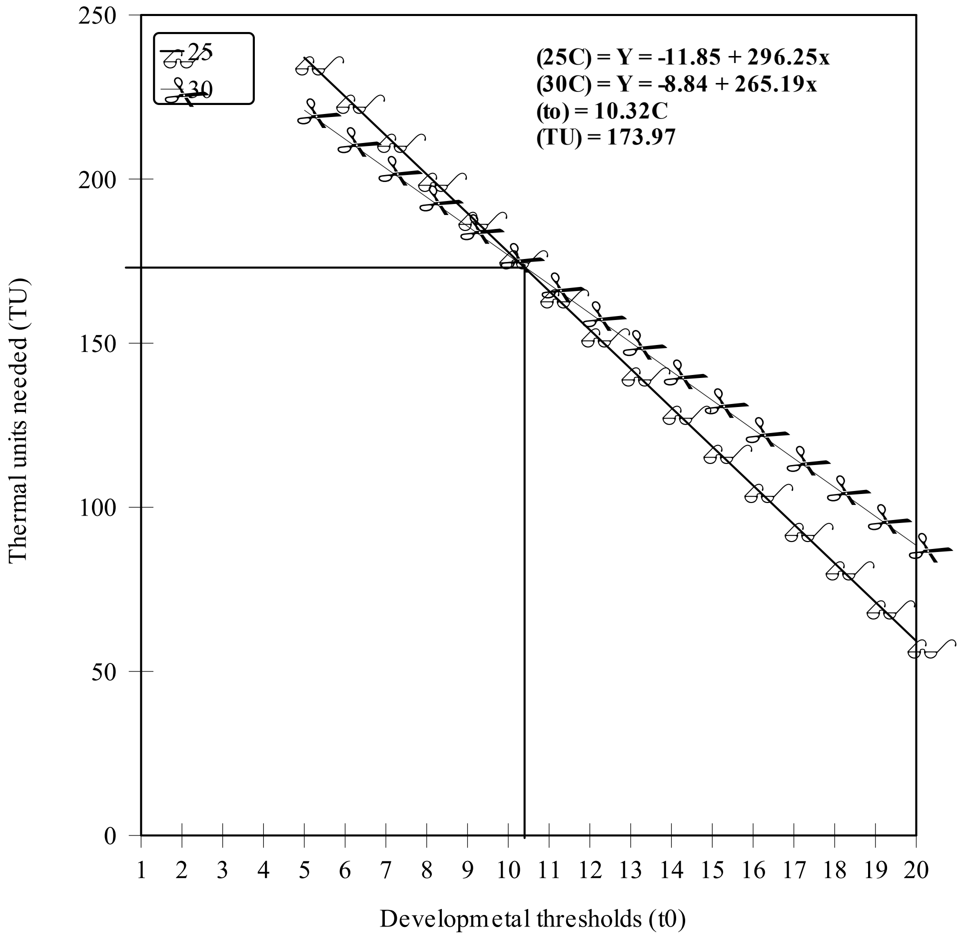

Figure (1): Developmental thresholds (t0) and thermail units (TU) needed for the devolpment of *T. urticae* reared at constant temperatures of 25 and 30C.

Table 3. Longevity (in days) and reproductive potential of *T. urticae* reared at constant temperatures of 25º and 30ºC.

Temp. (ºC)	Longevity (in days) and fecundity ± SE					
	Male	Female				
		Pre-	Ovi-position	Post-	Longevity	No. egg / ♀ (fecundity)
25	10.64 ± 4.34a	0.45 ± 0.61a	10.45 ± 2.25a	1.18 ± 1.32a	12.09 ± 2.43a	79.18±20.53a
30	7.00 ± 1.76b	0.20 ± 0.42a	5.40 ± 1.95b	1.40 ± 0.97a	7.00 ± 1.76b	45.70±24.28b

Means followed by the same letters vertically are not significantly different at 0.05 level of probability.

Table 4. Some life table parameters of *T. urticae* reared at constant temperatures of 25º and 30ºC.

Temp. (ºC)	(GT)	(DT)	(R_0)	Rate of increase	
				(r_m)	(λ)
25	18.31	3.22	51.47	0.2152	1.2401
30	12.19	2.52	28.50	0.2748	1.3163

(R_0) = Net reproductive rate, (GT) = Generation time, (DT) = Population doubling time, (r_m) = Intrinsic rate of natural increase, (λ) = Finite rate of increase.