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Effect of three fig cultivars and temperature on the biology and life-table parameters of *Tetranychus urticae* Koch (Acari: Tetranychidae)

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ABSTRACT

The effect of three fig cultivars *Ficus carica* L. (i.e., Adsi, Black michan, and Sultani) at three constant temperatures of 22, 27, and 32 °C, 70% RH, and 12 h photoperiod on the developmental duration and reproductive rate of the two-spotted spider mite *Tetranychus urticae* Koch was studied. Results indicated that temperature degree plays a key role in the time needed for *T. urticae* developmental stages to reach adulthood. Increasing the temperature accelerated the developmental rate and female fecundity and daily rate of egg production were positively affected**.** The shortest average life cycle was 10.0 & 10.03, 6.40 & 6.90, and 8.8 & 8.90 days for male and female at 32°C on Adsi, Black michan, and Sultani cultivars, respectively. Mean fecundity was highest at a temperature of 27°C (97.33 eggs/ female), and lowest was at 22°C (73.20 eggs/ female). The fig cultivar affected significantly on duration of immature stages, oviposition period, longevity, and average fecundity of *T. urticae.* The development thresholds (t_0) of the eggs and immature stages varied from 8.26 to 17.11°C, and the total effective temperatures (*K*) ranged from 40.42 to 152.17 degree-days for females. The highest intrinsic rate of increase (r_m) and net reproductive rate (R_0) was on 'Black michen' at 27 and 32ºC, while the lowest value was on 'Adsi' at 22 ºC. As the temperature increased, the values of the mean generation time (*T*) and generation doubling time (*DT*) decreased. Gross reproductive rate (*GRR*) was also affected by fig cultivar and temperature where the highest value was 94.8 offspring/ individual achieved when mites were kept at 27°C on 'Black michen' while the lowest value was 42.4 offspring/individual on 'Adsi' at 22°C. The results suggested that temperatures between 27 and 32°C are the most suitable conditions for the development, survival, and reproduction of *T. urticae.* While, the Black michen cultivar is the most favorable host for the development and reproduction of *spider mite T. urticae.*

Keywords: duration, spider mite, fecundity, susceptibility, *Ficus carica*, Egypt.

INTRODUCTION

The fig (*Ficus carica* L., Moraceae) is one of the woody, deciduous fruit trees. In Egypt, fig is mostly grown in the north coast of western desert which extends from Mersa Matrouh to Aswan governorates. Most people eat fig fruits fresh, though they can also be dried. Because it is a good supply of necessary amino acids, carbs, and minerals, as well as it is a rich source of vitamins (A, B1, B2, and C), in addition, fig has a high nutritional value (Sadhu 1990). Several phytophagous mites attack and can cause damages to fig orchards, which can result in a loss of economic yield (Desoky et al. 2021). On fig orchards, phytophagous mites feed on the sap of the plants, piercing leaf cells and sucking out the contents, which results in cell damage and death (Farrag et al. 1998 and Elsadany 2018).

Tetranychus urticae Koch (Acari: Tetranychidae), is a major mite pest in many cropping systems over the world. A number close to 1575 plant species such as vegetables, fruits, crops, and a variety of ornamental plants are infested by spider mites (Vacante 2016 and Migeon and Dorkeld 2024).

Any phytophagous species' biotic potential has a high correlation with how well its host species provides food and shelter (Kafil et al. 2007). The host plants and their nutritional value can have an impact on a variety of biological characteristics, including oviposition, duration of developmental period, and longevity.

In addition, life table has been considered as an excellent tool in ecological studies, providing information on the relationship between host plants and mites (Wermelinger et al. 1991; Kafil et al. 2007; Elsadany 2018; Elhalawany 2001, 2019 and Elhalawany et al. 2020).

Studies on the biology of *T.urticae* have been conducted by several authors, i.e., Elhalawany 2001; Kasap 2004; Praslička and Huszár 2004; Abdel-Wahed and Elhalawany 2012; Elhalawany and Abdel-Wahed 2013; Elsadany 2018 and Anber et al. 2020).

Therefore, the present study aims to study the effect of temperature and three fig cultivars on the development, survival, and life-table parameters of *Tetranychus urticae* under laboratory conditions. The results may prove useful for our understanding of the population dynamics of *T. urticae* on fig trees in Egypt.

MATERIALS AND METHODS

Biological studies of *Tetranychus urticae*

The stock colony of *T. urticae* was collected from fig in Gemmeiza Agriculture Research Station, Gharbia governorate. The stock culture of spider mite was maintained on mulberry (*Morus alba* L.) leaves in a rearing chamber (27±2ºC, 70±5% RH. and 12h photoperiod. Leaves infested with *T. urticae* were observed using a stereomicroscope. Some individuals were mounted in a Hoyer's medium and sent to specialists for a confirmation.

Mite rearing

Mites were reared on leaves of fig, where the rearing units consisted of plastic trays (20 x 4 cm), each tray containing a foam disc (1cm thick) on which a leaf disc of fig (2.5 cm in diameter) was placed upside down. The leaf margin was covered with a fine cotton pad completely soaked in distilled water to prevent mites from escaping. The foam discs were moistened daily and kept in a growth chamber under the following environmental conditions at (22, 27 and 32±2°C; 70±5% RH. and 12h photoperiod).

Development and biology of *T. urticae* were conducted on three fig cultivars (i.e., Adsi, Black michan, and Sultani). For every cultivar, one leaflet was selected from the first completely growing leaf on each plant. To obtain removed of any potential mites or residue, everything was thoroughly washed under running water. A tangle foot was used to surround 2.5 cm diameter leaf discs, which were then, positioned lower side up on moistened cotton wool in Petri plates (12 cm diameter). For each cultivar, couple of male and female of *T. urticae* was placed on each disc. These Petri dishes were kept for 24 hours to allow mating, subsequently, males were removed, while female served as a source for known-age eggs, and larvae. About 50 hatching larvae were kept singly to a leaf of each variety and left to continue their life span. In order to measure the duration (in days) of each developmental stage, life cycle, generation time, the pre-oviposition, oviposition, and post-oviposition periods and lifespan of males and females. The number of eggs laid by a single female and the daily rate of egg production were recorded during the longevity of female at the three tested constant temperatures according to Abdel-Wahed and Elhalawany (2012).

During developmental period, mortalities of different stages and sex ratio of progeny were specified. Life table parameters were estimated according to Birch (1948) using the Life 48, BASIC Computer programmed (Abou-Setta et al. 1986). Parameters were determined by the following formula:

$$\max \Sigma_0 \; Lx \; m \; x \; / \; \exp. \; r_m \; x = 1$$

Where "m_x" is the number of daughters produced per female during the interval "*x*". "L_x" is the fraction of lively females at age "*x*". The values of "r_m" is a natural logarithm of the intrinsic rate of increase and indicates the number of times of population multiplication in a of time unit. The net reproductive rate (R_0) is the mean for female multi-placation in one generation (. "*T*" is the mean length of generation period, expressed in days, while *DT* means time of population to double, and "*GRR*" means Gross reproduction rate calculated. These definitions were presented by Birch (1948). $R_0 = \Sigma(l_x \times m_x)$; $T = \Sigma(x \times l_x \times m_x) / \Sigma(l_x \times m_x)$; $r_m = \text{Ln}(R_0)/T$; $DT = \text{Ln}(2)/ r_m$, $\lambda = \exp(r_m)$ and $GRR = \Sigma mx$.

Statistical analysis

The duration of different life stages of mites, reproduction and fecundity parameters were compared between the three fig cultivars using one way analysis of variance (ANOVA) by using SAS statistical software (SAS Institute, 2003). Mean separation was conducted using Tukey's HSD (P = 0.05) in the same program. The

relationship between temperature and mean developmental rate of each stage under tested temperatures was determined using liner regression, Y= a ± bx, whereas: a=Intercept, b=slope of temperature. The two constants, the lower developmental threshold t_0 = – a/b (°C) and thermal units K = 1/b (In DDUs), were determine where: t_0 is developmental threshold °C; b is the developmental rate line slope and K is the developmental heat constant in degree-days.

RESULTS AND DISCUSSION

The present data proved that the two-spotted spider mite *T. urticae* successfully developed on the three fig cultivars (Adsi, Black michan, and Sultani) at the three constant tested temperatures 22, 27, and 32 °C, 70% RH, and 12 h photoperiod.

Developmental time and reproduction rate of *Tetranychus urticae* at 22°C.

The duration of its several developmental stages on three fig cultivars, Adsi, Black michan, and Sultani, at 22˚C is presented in Table (1). The results clearly indicated that *T. urticae* larvae hatched after the shortest egg incubation period of 8.20 days on 'Black michen' while it took the longest duration of 9.30 days on Adsi cultivar at 22°C. The shortest durations of different stages, life cycles and life spans were recorded on 'Black michen', whereas the longest one was recorded on Adsi cultivar. The longest oviposition period was 16.20 days on Black michen cultivar, while the shortest period was 13.40 days on the Adsi cultivar with significant differences. The longest adult female longevity observed on 'Black michen' was 20.10 days, while the shortest was 18.75 and 18.70 days on Adsi and Sultani cultivars, respectively. The highest mean number of eggs laid by females was 87.0 eggs per female, with a daily rate of 5.37 eggs per day on 'Black michen'. The lowest fecundity was 63.60 and 69.0 eggs/♀ on Adsi and Sultani cultivars, with a daily rate of 4.73 and 4.79 eggs/♀/day, respectively.

Data presented in Table (2) showed a significant difference between the effect of the three fig cultivars on different biological aspects of *T. urticae* males. The shortest male larva, protonymphal, deutonymphal stages, total immature stages, lifecycle, and life span were recorded on Black michen cultivar at 22°C, while the longest periods were recorded on Adsi cultivar.

Table 1. Mean duration (days) (±SE) of immature and adult *Tetranychus urticae* females reared on different fig cultivars at 22±2°C.

Parameters	Fig cultivars			Average	F-value	P-value	HSD
	Adsi	Black michen	Sultani				
Incubation period	9.30±0.14 a	8.20±0.06 c	8.70±0.11 b	8.73	26.40	<.0001	0.36
Larva	4.43±0.16 a	3.33±0.05 c	3.90±0.18 b	3.89	14.46	<.0001	0.48
Protonymph	4.28±0.13 a	3.20±0.06 c	3.68±0.14 b	3.72	21.95	<.0001	0.39
Deutonymph	4.13±0.17 a	2.90±0.09 c	3.45±0.17 b	3.49	17.74	<.0001	0.49
Total immature stages	12.83±0.34 a	9.43±0.10 c	11.03±0.43 b	11.10	28.19	<.0001	1.09
Life cycle	22.13±0.41 a	17.63±0.14 c	19.73±0.50 b	19.83	34.08	<.0001	1.13
Generation period	24.73±0.48 a	19.43±0.19 c	21.73±0.50 b	21.96	40.85	<.0001	1.41
Pre-oviposition period	2.60±0.14 a	1.80±0.09 b	2.00±0.07 b	2.13	15.81	<.0001	0.35
Oviposition period	13.40±0.23 c	16.20±0.27 a	14.40±0.28 b	14.67	29.89	<.0001	0.88
Post-oviposition period	2.75±0.13 a	2.10±0.11 b	2.30±0.14 b	2.38	6.92	0.0020	0.43
Longevity	18.75±0.37 b	20.10±0.22 a	18.70±0.21 b	19.18	8.15	0.0008	0.94
Mean fecundity (eggs/ ♀)	63.60±1.97 c	87.00±1.72 a	69.00±1.34 b	73.20	52.23	<.0001	5.76
Daily rate (eggs/ ♀/ day)	4.73±0.07 b	5.37±0.02 a	4.79±0.04 b	4.96	51.39	<.0001	0.16
Life span	40.88±0.68 a	37.73±0.30 b	38.43±0.58 b	39.01	9.34	<.0003	1.84

Means followed by the same letter within a row do not differ statistically by Tukey test at 5% probability.

Table 2. Mean duration (days) (±SE) of immature and adult of *Tetranychus urticae* males reared on different fig cultivars at 22±2°C.

Parameters	Fig cultivars			Average	F-value	P-value	HSD
	Adsi	Black michen	Sultani				
Incubation period	8.80±0.34 a	8.15±0.08 a	8.55±0.29 a	8.50	1.58	0.2241	0.91
Larva	4.00±0.22 a	3.20±0.11 b	3.70±0.19 ab	3.63	5.07	0.0135	0.62
Protonymph	3.95±0.22 a	3.10±0.10 b	3.35±0.13 b	3.47	7.75	0.0022	0.55
Deutonymph	3.80±0.30 a	2.85±0.13 b	3.40±0.22 ab	3.35	4.38	0.0225	0.79
Total immature stages	11.75±0.44 a	9.15±0.24 b	10.45±0.40 ab	10.45	12.21	<.0002	1.30
Life cycle	20.55±0.57 a	17.30±0.28 b	19.00±0.45 a	18.95	12.90	<.0001	1.58
Longevity	15.30±0.54 a	16.00±0.52 a	15.60±0.52 a	15.63	0.45	0.6442	1.84
Life span	35.85±0.80 a	33.30±0.69 b	34.60±0.59 ab	34.58	3.34	0.0507	2.44

Means followed by the same letter within a row do not differ statistically by Tukey test at 5% probability.

Developmental time and reproduction rate of *T. urticae* at 27°C.

The obtained results are presented in Tables (3 and 4) showed that significant differences were found between the effect of the three fig cultivars at 27 °C. The shortest female incubation period, larval stage, protonymphal stages, deutonymphal stages, life cycle, and generation period were 3.45, 1.73, 1.35, 1.55, 8.08, and 9.38 days on Black michen cultivar, while the longest were 4.40, 2.70, 2.30, 2.60, 12.0, and 13.80 days on Adsi cultivar when mites were kept at 27°C, respectively. The highest mean fecundity of females was 118.0 eggs/♀ with a daily rate of 7.65 eggs/♀/day on Black michen cultivar, whereas the lowest was 86.0 and 88.0 eggs/♀ with a daily rate of 7.74 and 6.58 eggs/♀/day on Adsi and Sultani cultivars, respectively. There were significant differences in the duration of oviposition period and longevity between the three fig cultivars when mites were kept at 27 °C.

Table 3. Mean duration (days) (±SE) of immature and adult of *Tetranychus urticae* females reared on different fig cultivars at 27±2°C.

Parameters	Fig cultivars			Average	F-value	P-value	HSD
	Adsi	Black michen	Sultani				
Incubation period	4.40±0.09 a	3.45±0.09 c	3.80±0.06 b	3.88	37.86	<.0001	0.27
Larva	2.70±0.06 a	1.73±0.07 c	2.20±0.06 b	2.21	65.50	<.0001	0.20
Protonymph	2.30±0.09 a	1.35±0.10 c	2.00±0.07 b	1.88	30.73	<.0001	0.29
Deutonymph	2.60±0.13 a	1.55±0.14 c	2.20±0.06 b	2.12	21.41	<.0001	0.38
Total immature stages	7.60±0.23 a	4.63±0.23 c	6.40±0.11 b	6.21	54.88	<.0001	0.68
Life cycle	12.00±0.24 a	8.08±0.24 c	10.20±0.12 b	10.09	89.19	<.0001	0.70
Generation period	13.80±0.22 a	9.38±0.23 c	12.00±0.14 b	11.73	122.3	<.0001	0.68
Pre-oviposition period	1.80±0.06 a	1.30±0.06 b	1.80±0.11 a	1.63	14.39	<.0001	0.25
Oviposition period	11.20±0.27 c	15.60±0.31 a	13.40±0.23 b	13.40	65.07	<.0001	0.92
Post-oviposition period	2.20±0.12 a	2.05±0.10 a	1.93±0.14 a	2.06	1.29	0.406	0.41
Longevity	15.20±0.17 c	18.95±0.26 a	17.13±0.31 b	17.09	54.85	<.0001	0.86
Mean fecundity (eggs/ ♀)	86.00±0.86 b	118.0±2.36 a	88.0±1.56 b	97.33	110.34	<.0001	5.80
Daily rate (eggs/ ♀/ day)	7.74±0.14 a	7.65±0.26 a	6.58±0.09 b	7.32	12.80	<.0001	0.61
Life span	27.20±0.38 a	27.03±0.41 a	27.33±0.32 a	27.19	0.16	0.6762	1.26

Means followed by the same letter within a row do not differ statistically by Tukey test at 5% probability.

Table 4. Mean duration (days) (±SE) of immature and adult of *Tetranychus urticae* males reared on different fig cultivars at 27±2°C.

Parameters	Fig cultivars			Average	F-value	P-value	HSD
	Adsi	Black michen	Sultani				
Incubation period	4.20±0.23 a	3.40±0.12 b	3.65±0.13 ab	3.75	6.01	0.0069	0.58
Larva	2.60±0.07 a	1.70±0.08 c	2.25±0.11 b	2.18	26.15	<.0001	0.31
Protonymph	2.20±0.17 a	1.30±0.13 b	2.00±0.11 a	1.83	11.60	0.0002	0.48
Deutonymph	2.50±0.21 a	1.60±0.19 b	2.15±0.08 ab	2.08	7.01	0.0035	0.60
Total immature stages	7.30±0.40 a	4.60±0.34 b	6.40±0.18 a	6.10	18.29	<.0001	1.12
Life cycle	11.50±0.54 a	8.00±0.35 c	10.05±0.20 b	9.85	20.50	<.0001	1.36
Longevity	14.40±0.50 a	16.00±0.52 a	15.90±0.43 a	15.43	2.51	0.0472	1.69
Life span	25.90±0.85 a	24.00±0.69 a	25.95±0.53 a	25.28	2.25	0.1003	2.46

Means followed by the same letter within a row do not differ statistically by Tukey test at 5% probability.

Developmental time and reproduction rate of *T. urticae* at 32°C.

The presented results in Tables (5 and 6) showed that significant differences were found between the three fig cultivars at 32°C. The shortest female incubation period, larval stage, protonymphal stages, deutonymphal stages, life cycle, and generation period were 2.48, 1.53, 1.50, 1.40, 6.90, and 8.30 days on Black michen cultivar, while the longest ones were 3.13, 2.60, 2.10, 2.20, 10.03, and 11.40 days on Adsi cultivar at 32°C, respectively. Females had longer longevity period 13.40 days when *T. urticae* fed on Black michen cultivar, as well as longer oviposition period 10.40 days, with significant difference. No significant difference between pre-oviposition period and life span among the three fig cultivars. As for the fecundity of the highest mean numbers of eggs per female were observed in Black michen cultivar was 106.6 eggs/♀, while the lowest was 81.60 and 84.0 eggs/♀ on Adsi and Sultani cultivars with significant difference, respectively.

Similar results were in agreement with those obtained by Elhalawany (2001), who found that the shortest developmental time of female and male *T. urticae* was recorded at 30°C as (10.15& 9.29 and 7.95 and 7.34 days) when fed on Adsi and Sultani fig cultivars, respectively). The longest longevity of spider mite female was obtained at 15°C on apple cultivars, Kasap (2004) showed that the development periods of immature stages of *T. urticae* were 6.5 & 5.9 days at 35 °C and 15.5 & 14.5 days at 20 °C for females and males, respectively. Similarly, Praslička and Huszár (2004) reported that *T. urticae* developed fastest on *Phaseolus vulgaris* (9.42 days), followed by *Cucumis sativus* (10.26 days) and *Capsicum annuum* (10.92 days). The average fecundity was 79.28 eggs on *P. vulgaris*, 71.48 eggs on *C. annuum* and 71.22 eggs on *C. sativus*. Abdel-Wahed and Elhalawany (2012) found that the highest fecundity and daily rate of spider mites kept at 30°C was 150.1 eggs/ female and 15.30 eggs/♀/day on pear trees, while the lowest was at 15°C as 40.5 eggs/female and 2.44 eggs/♀/day. Elhalawany and Abdel-Wahed (2013) showed that temperatures between 25 to 28°C to be most favorable to the *T.urticae* development on Persimmon trees. Anber et al. (2020) found that the lowest longevity of *T. urticae* was 13.65 days on the soybean Giza21 cultivar, while the lifespan of females was 18.18 days at 22°C.

Table 5. Mean duration (days) (±SE) of immature and adult of *Tetranychus urticae* females reared on different fig cultivars at 32±2°C.

Parameters	Fig cultivars			Average	F-value	P-value	HSD
	Adsi	Black michen	Sultani				
Incubation period	3.13±0.08 a	2.48±0.08 b	2.68±0.08 b	2.76	17.28	<.0001	0.27
Larva	2.60±0.09 a	1.53±0.10 c	2.30±0.08 b	2.14	40.15	<.0001	0.29
Protonymph	2.10±0.11 a	1.50±0.10 b	2.13±0.09 a	1.91	12.16	<.0001	0.34
Deutonymph	2.20±0.06 a	1.40±0.09 c	1.80±0.06 b	1.80	35.08	<.0001	0.22
Total immature stages	6.90±0.17 a	4.43±0.08 c	6.23±0.12 b	5.85	97.32	<.0001	0.44
Life cycle	10.03±0.18 a	6.90±0.11 c	8.90±0.14 b	8.61	117.3	<.0001	0.49
Generation period	11.40±0.21 a	8.30±0.16 c	10.45±0.17 b	10.05	75.77	<.0001	0.62
Pre-oviposition period	1.38±0.10 a	1.40±0.11 a	1.55±0.10 a	1.44	0.87	0.0533	0.34
Oviposition period	8.20±0.27 b	10.40±0.23 a	9.00±0.32 b	9.20	16.06	<.0001	0.94
Post-oviposition period	0.90±0.09 c	1.60±0.09 a	1.20±0.06 b	1.23	20.68	<.0001	0.26
Longevity	10.48±0.27 c	13.40±0.29 a	11.75±0.35 b	11.88	22.85	<.0001	1.04
Mean fecundity (eggs/ ♀)	81.60±1.22 b	106.6±1.34 a	84.00±1.69 b	90.73	93.10	<.0001	4.86
Daily rate (eggs/ ♀/ day)	10.10±0.29 a	10.38±0.33 a	9.70±0.55 a	10.06	0.73	0.4519	1.37
Life span	20.50±0.28 a	20.30±0.25 a	20.65±0.33 a	20.48	0.37	0.629	0.98

Means followed by the same letter within a row do not differ statistically by Tukey test at 5% probability.

Table 6. Mean duration (days) (±SE) of immature and adult of *Tetranychus urticae* males reared on different fig cultivars at 32±2°C.

Parameters	Fig cultivars			Average	F-value	P-value	HSD
	Adsi	Black michen	Sultani				
Incubation period	3.10±0.10 a	2.45±0.12 b	2.60±0.12 b	2.72	8.87	0.0011	0.40
Larva	2.10±0.12 a	1.40±0.15 b	2.20±0.08 a	1.90	13.15	0.0001	0.42
Protonymph	2.40±0.15 a	1.30±0.13 b	2.10±0.07 a	1.93	22.38	<.0001	0.42
Deutonymph	2.40±0.16 a	1.25±0.08 c	1.90±0.15 b	1.85	18.23	<.0001	0.47
Total immature stages	6.90±0.26 a	3.95±0.19 b	6.20±0.19 a	5.68	52.47	<.0001	0.74
Life cycle	10.00±0.22 a	6.40±0.24 c	8.80±0.17 b	8.40	72.58	<.0001	0.75
Longevity	10.10±0.53 a	10.50±0.50 a	10.10±0.43 a	10.23	0.22	0.8810	1.71
Life span	20.10±0.51 a	16.90±0.55 b	18.90±0.33 a	18.63	11.72	0.0002	1.65

Means followed by the same letter within a row do not differ statistically by Tukey test at 5% probability.

Effect of fig cultivars on different biological aspects of *T. urticae*

The present experiments revealed that there were significant differences found between all developmental periods of mites exposed to different host plants. The duration of all developmental stages were longer on 'Adsi' cultivar followed by 'Sultani' and 'Black michen' as shown in Table (7). The results in Tables (7 and 8) showed that significant differences were recorded between the three fig cultivars on the average egg incubation period, duration of larval, protonymphal, deutonymphal, and total immature stages. The longest periods were 5.61 &5.37, 3.24 & 2.90, 2.89 & 2.85, 2.98 & 2.90, and 9.11 & 8.65 days on Black michen cultivar, however, the shortest values were observed on Adsi cultivar (4.71 & 4.67, 2.20 & 2.10, 2.02 & 1.90, 1.95 & 1.90, and 6.16 & 5.90 days) on spider mite female and male, respectively. The shortest generation period was recorded on 'Black michen', while the longest one was on 'Adsi'. Additionally, significant differences between adult female longevity, fecundity, and oviposition period were generally found. The Black michen was more favored and followed by the Sultani and Adsi cultivars, the differences in fecundity could be related to leaf structural morphology of host plants. Insignificant differences were recorded for female life span among the three fig cultivars. Males followed a similar trend, but had generally shorter periods.

These results are in accordance with those previously obtained by Elhalawany (2001) who showed that Black michen fig cultivar prolonged oviposition period, longevity and fecundity of *T. urticae* than Adsi cultivar, and this may be due to

the such variety has high contents of Nitrogen, Phosphorus and total Sugars than in Adsi fig cultivar. Awad et al. (2018) reported that life cycle of *T. urticae* averaged 11.92 and 12.98 days when fed on persimmon and pecan leaves at 27°C. Elsadany (2018) also found that developmental and reproduction rate of *T. urticae* are influenced by tissue nutrient content for host plant. Osman et al. (2019) reported that *T. urticae* fecundity was highly affected by host plants. They mentioned that the highest fecundity was noted for spider mites reared on *Cucumis sativus* (90 eggs/♀) and followed by those reared on *Phaseolus vulgaris* (84 eggs/♀).

Table 7. Effect of fig cultivars on different biological aspects of *Tetranychus urticae* female at different constant temperatures.

Parameters	Fig cultivars			F-value	P-value	HSD
	Adsi	Black michen	Sultani			
Incubation period	5.61±1.88 a	4.71±1.77 c	5.06±1.85 b	44.91	0.0001	0.34
Larva	3.24±0.59 a	2.20±0.57 c	2.80±0.55 b	113.9	<.0001	0.24
Protonymph	2.89±0.70 a	2.02±0.59 c	2.60±0.54 a	21.17	0.0006	0.48
Deutonymph	2.98±0.59 a	1.95±0.48 c	2.48±0.50 b	53.56	0.0013	0.35
Total immature stages	9.11±1.87 a	6.16±1.63 c	7.89±1.57 b	72.0	0.0007	0.87
Life cycle	14.72±3.75 a	10.87±3.40 c	12.94±3.41 b	75.89	0.0007	1.11
Generation period	16.64±4.10 a	12.37±3.54 c	14.73±3.53 b	35.17	0.0029	1.81
Pre-oviposition period	1.93±0.36 a	1.50±0.15 a	1.78±0.13 a	2.28	0.2180	0.72
Oviposition period	10.93±1.51 b	14.07±1.84 a	12.27±1.66 b	21.96	0.0070	1.69
Post-oviposition period	1.95±0.55 a	1.92±0.16 a	1.81±0.32 a	0.13	0.9360	1.0
Longevity	14.81±2.40 b	17.48±2.07 a	15.86±2.10 b	12.82	0.0182	1.89
Mean fecundity (eggs/♀)	77.07±6.85 b	103.87±9.05 a	80.33±5.78 b	63.06	0.0009	9.28
Daily rate (eggs/ ♀/ day)	7.52±1.55 a	7.80±1.45 a	7.02±1.43 a	4.81	0.0862	0.99
Life span	29.53±6.0 a	28.35±5.08 a	28.80±5.19 a	1.21	0.3883	2.71

Means (±SE) followed by same letters do not differ significantly by Tukey's HSD (P< 0.05).

Table 8. Effect of fig trees cultivars on different biological aspects of *Tetranychus urticae* males at different constant temperatures.

Parameters	Fig cultivars			F-value	P-value	HSD
	Adsi	Black michen	Sultani			
Incubation period	5.37±1.75 a	4.67±1.76 c	4.93±1.83 b	45.69	0.0018	0.26
Larva	2.90±0.57 a	2.10±0.56 b	2.72±0.49 a	32.71	0.0033	0.36
Protonymph	2.85±0.55 a	1.90±0.60 b	2.48±0.43 a	28.17	0.0044	0.45
Deutonymph	2.90±0.45 a	1.90±0.49 c	2.48±0.46 b	170.3	<.0001	0.19
Total immature stages	8.65±1.55 a	5.90±1.64 c	7.68±1.38 b	99.62	0.0004	0.70
Life cycle	14.02±3.30 a	10.57±3.40 c	12.62±3.21 b	289.0	<.0001	0.51
Longevity	13.27±1.60 a	14.17±1.83 a	13.87±1.89 a	3.60	0.1276	1.21
Life span	27.28±4.60 a	24.73±4.75 b	26.48±4.54 a	27.40	0.0046	1.25

Means (±SE) followed by same letters do not differ significantly by Tukey's HSD (P< 0.05).

Effect of temperature on biological aspects of *T. urticae*

Data in Table (9 and 10) showed that the lower threshold temperature (t_0) to different stages of *T. urticae* was 17.11& 16.99, 8.26 & 10.28, 9.68 & 7.31, 10.73 & 8.83 and 9.58 & 8.91 for egg, larva, protonymph, deutonymph, and total immature for mite females, respectively. The lower temperature thresholds that let male and female *T. urticae* completed their growth were 13.53 and 13.25°C, respectively as shown in Tables (9 and 10). The mean numbers of DDUs required by *T. urticae* for egg to-adult were 152.17 and 150.88°C, for female and male, respectively. The overall development rate of *T. urticae* females increased linearly with rising temperature. R^2 value of *T. urticae* was 0.93 of life cycle for female as well as male.

These results agree with those obtained by Ismail (2009) who studied the biology of the

citrus spider mite *Panonychus citri* (McGregor) on sweet orange leaves and discovered that the total effective temperature was 100 and 192.30 degree-days, and that the development thresholds for female eggs and immature stages were 9.22 °C and 9.77 °C, respectively. Elhalawany and Abdel-Wahed (2013) found that the lower thresholds (*t0*) of spider mites reared on 'Kostata' persimmon variety was 11.63, 5.55, 5.35, and 8.32 for of egg, larva, protonymph and deutonymph, respectively. Riahi et al. (2013) also found that lower threshold temperature (t_0) of *T. urticae* was 13.79°**C**, the accumulated day degrees (K) 136.43 degree-days required to complete development. Anbar et al. (2020) reported that the (t_0) of *T. urticae* reached 14.26, 3.44, 6.34, 11.32, 7.93, and 11.32 and the accumulated day degrees (K) were 47.96, 41.36, 30.0, 25.27, 92.12, and 135.4, DDUs for , for egg, larva, protonymph, deutonymph, total immature and life cycle, respectively.

Table 9. Values of linear regression analysis for the effect of temperature on the developmental rate of *Tetranychus urticae* females

Parameters	*A*	*b*	t_0	*K*	R^2
Egg	-0.42	0.02	17.11	40.42	0.99
Larva	-0.17	0.02	8.26	47.78	0.80
Protonymph	-0.25	0.03	9.68	39.26	0.73
Deutonymph	-0.29	0.03	10.73	37.13	0.95
Immature stages	-0.08	0.01	9.58	123.88	0.84
Life cycle	-0.09	0.01	13.53	152.17	0.93

a=Intercept, b= slope of temperature, t_0= (-a/b)°C, K= (1/b) degree-days.

Table 10. Values of linear regression analysis for the effect of temperature on the developmental rate of *Tetranychus urticae* males developmental rate

Parameters	*A*	*b*	t_0	*K*	R^2
Egg	-0.43	0.03	16.99	39.93	0.99
Larva	-0.26	0.03	10.28	39.83	0.94
Protonymph	-0.17	0.02	7.31	43.71	0.66
Deutonymph	-0.21	0.02	8.83	41.32	0.92
Immature stages	-0.07	0.01	8.91	124.60	0.86
Life cycle	-0.09	0.01	13.25	150.88	0.93

a=Intercept, b= slope of temperature, t_0= (-a/b)°C,K= (1/b) degree-days.

Life table parameters of *T. urticae* under different rearing conditions

The life table parameters of *T. urticae* at three constant temperatures and three fig cultivars are shown in Table (11). The results clearly showed that mean generation time (*T*) negatively correlated with temperature where it declined with increasing temperature. The shortest doubling generation time (*DT*) recorded on 'Black michen' was 1.83 days when spider mite reared at 32°C, while the longest period was achieved on Adsi cultivar (5.64 days) when mites were kept at 22°C. Gross reproduction rate (*GRR*), which recorded at 27°C on 'Black michen', was 94.8 offspring/individual and the lowest value was 42.4 offspring/individual on Adsi cultivar. The net reproductive rate (R_o) increased from 32.24 ♀/♀ on Adsi cultivar at 22°C to 76.22 ♀/♀ on 'Black michen' at 27°C. The maximum intrinsic rate of natural increase (r_m) was recorded at 32°C on 'Black michen' (0.379 ♀/♀/day), whereas the lowest value was (0.123 ♀/♀/day) on Adsi cultivar at 22°C. The sex ratio ranged from 0.60 at 22°C on Adsi cultivar to 0.76 females per total at 27°C on 'Black michen'. The survival rate ranges from 70.0% to 87.0%.

The present results are similar to those obtained by Kasap (2004) who found that the mean generation time of spider mites was 9.94 days at 35°C, with a net reproduction rate increasing from 66.99 ♀/♀ at 20°C to 92.19 ♀/♀ at 25°C when mite was reared on apple. Riahi et al. (2013) also noted that the intrinsic rate of increase (r_m) of spider mite reared on peach leaves at different temperatures ranged from 0.108 to 0.213 day^{-1}, with the highest value recorded at 27°C. On the other hand, Elhalawany (2013) mentioned that the date palm red spider

mite, *Oligonychus afrasiaticus* (McGregor) had r_m, R_0 and λ increased with temperature increase. Elhalawany and Abdel-Wahed (2013) showed that the shortest time for population density doubling (*DT*) of spider mite on persimmon was 2.85 and 2.33 days at 30ºC. The highest (r_m) was obtained at 30°C (0.243 ♀/♀/day) on Kostata cultivar. Elhalawany (2019) also reported that the mean generation time (*T*) and generation doubling time (*DT*) values of citrus brown mite, *Eutetranychus orientalis* (Klein) decreased with increasing temperature when reared on leaves of six different host plants. Osman et al. (2019) similarly showed that the highest (r_m) of *T. urticae* was on leaves of *Phaseolus vulgaris* (0.233 ♀/♀/day) and the lowest value when mites reared on *Solanum melongena* (0.198 ♀/♀/day).

Table 11. Life-table parameters of *Tetranychus urticae* female reared on four fig trees cultivars at three different constant temperatures

Parameter	Fig cultivars								
	Adsi			Black michen			Sultani		
	22°C	27°C	32°C	22°C	27°C	32°C	22°C	27°C	32°C
Gross reproductive rate (*GRR*)[d]	42.4	62.9	70.4	72.0	94.8	75.6	51.3	69.4	67.6
Sex ratio (♀♀/total)	0.60	0.75	0.75	0.75	0.76	0.70	0.68	0.72	0.70
Survival rate %	82.0	80.0	70.0	85.0	85.0	80.0	87.0	80.0	70.0
Net reproductive rate (R_0)[b]	32.24	47.04	42.84	55.46	76.22	54.09	40.82	50.68	41.45
Mean generation time (*T*)[a]	27.86	15.98	13.32	23.99	12.90	10.51	25.49	15.09	12.26
Intrinsic rate of increase (r_m) [C]	0.123	0.240	0.281	0.167	0.335	0.379	0.145	0.260	0.303
Finite rate of increase (λ)[C]	1.13	1.27	1.32	1.18	1.39	1.46	1.15	1.29	1.35
Doubling time (*DT*) [a]	5.64	2.89	2.47	4.15	2.07	1.83	4.78	2.67	2.29

[a]Days, [b]♀/♀,[c]♀/♀/day, [d] offspring/individual.

CONCLUSION

Results indicated that temperature plays a key role in the time needed for *T. urticae to* reach adulthood. Increasing temperature accelerated the developmental rate, but female fecundity and daily rate were positively affected**.** The obtained results suggested that temperatures between 27 and 32°C are the most suitable conditions for the development, survivorship, and reproduction of *T. urticae*. The Black michen fig cultivar was the most favorable host for the development and reproduction of *spider mite T. urticae.*

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