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Biology and life table parameters of *Aceria melongena* (Trombidiformes: Eriophyidae) on eggplant

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ABSTRACT

Developmental time, survival, reproduction and life table parameters of the eriophyid mite, *Aceria melongena* (Zaher & Abou-Awad) at three constant temperatures (20, 26, and 32°C) on eggplant, *Solanum melongena* L. (Solanaceae) leaves were presented. All immature stages developed faster when temperature was increased from 20 to 32°C. Females' developmental time was the longest at 20°C (14.43 days), followed by 26°C (9.45days). The shortest one was 6.63 days at 32°C. Fecundity and daily oviposition rates were the highest at 32°C (20.64 eggs/female and 1.36 eggs/female/day). The lowest ones were 14.84 eggs/female and 1.16 eggs/female/day at 20°C. Females/total ranged between 0.60 and 0.65 regardless tested temperatures. Relationships between developmental rates at different temperature were fitted to a linear model with R^2 values which ranged between 0.972 and 0.997 for egg, larva, nymph and life cycle, with K values (degree-days) of respectively 36.03, 72.42, 49.69, and 148.84. The highest net reproductive rate (R_0) and intrinsic rate of increase (r_m) were 11.25 females/female and 0.191 females/female/day at 32°C. These values suggested that the optimal temperature for the population growth of *A. melongena* ranged between 26 and 32°C. These results could be used to create a computer simulation model that forecast the growth and population dynamics of *A. melongena* on eggplant.

Keywords: Eggplant rust mite, life history, temperature, intrinsic rate of increase, biological aspects, forecast

INTRODUCTION

Eriophyoid mites have a close bond with their host plants and can only develop on a specific assortment of plants. About 80% of eriophyoid mites are reported on one host plant, of which about 95% were pertained to one genus and 99% to a single family (Skoracka et al. 2010).

The eggplant rust mite, *A. melongena* (=*Eriophyes melongenus*) was recorded for the first time at Alexandria governorate, Egypt on eggplant, *S. melongena*. Nowadays, it is distributed all over governorates. The mite is frequently infesting new and well developed leaves preferring the lower surface. During high infestation, it is noticed on both surfaces and around the leaf petiole, causing yellowish colour in distorted leaves and reduced development (Zaher and Abou-Awad 1979; Farahat 2020). *Aceria melongena* feeds on epidermal cells, leaves and buds, produces a greasy appearance, which becomes bronzed. Highly infested leaves curl upwards, become dry and causing yellowish colour and distorted leaves drop. The mite has a simple life cycle, after hatching, it pass through two developmental stages (larva and nymph), then adults after a resting period. The adult female wormlike, yellowish in colour; eggs is circular and translucent, and then turned to yellowish before hatching (Zaher and Abou-Awad 1979; Farahat 2020).

Biology of *A. melongena* on eggplant was studied previously by Farahat (2020). He mentioned that its life cycle ranged from 6.38 to 17.80 days according to eggplant cultivar and temperature. The longest oviposition period was 17.41 days and the highest fecundity rate was 48.10 eggs/female on Batra cultivar at 31ºC. Also, the author indicated that *A.melongena* is one of the most important and injurious species of the family Eriophyidae infesting different eggplant cultivars. The Black beauty cultivar was relatively more resistant to the mite infestation than Batra and N-suma cultivars. He also reported about 12 generations of *A. melongena* during growing season on Batra cultivar, with four peaks recorded in May, Sept., Oct. and Nov. during the growing season.

The aim of the present study is to determine the effect of temperature on various biological aspects and the life table parameters of *A. melongena* on Magd eggplant cultivar at three constant temperatures.

MATERIALS AND METHODS

A colony of *A. melongena* was collected from eggplant leaves in Shebeen El-Kom, Monufia governorate, Egypt during summer season of 2021. The mites were cleared in Keifer’s solution at room temperature and mounted on glass-microscope slides in Keifer's F-medium (Amrine and Manson 1996). The specimens were identified according to the key of Zaher (1984). Stock colonies of *A. melongena* were reared on eggplant leaves at 25±1°C, 60±5% RH and 16:8 h (L: D) photoperiod for two generations before stating the experiments.

Experimental units

Experiments were conducted on arenas consisted of discs of Magd eggplant cultivar leaves (2.5 cm in diameter), placed upside down on water saturated cotton; inside plastic Petri dishes (6 cm in diameter). Leaves were well washed with running water to remove any mite individuals. Petri dishes were covered by fine mesh for ventilation. The mites were transferred into new arenas when needed. The experiments were conducted at three constant temperatures (20, 26, and 32°C and 60±5% R.H.

Development and biology of *A. melongena* at three constant temperatures

Sixty newly emerged adults (males and females) were extracted from stock culture and placed on 30 arenas (2.5 cm in diameter) for 24 h in order to lay eggs on each temperature. After laying eggs, females and males were removed. Inspection was carried out twice daily under a stereoscopic microscope of 40-100 magnification force, until the mites reached adulthood. The changes were recorded until the death of the last female. When a female nymph emerged at each temperature, one adult male obtained from the mite culture was offered onto the leaf disc to increase the probability of sufficient insemination of females. The number of laid eggs by each female was recorded and the sex ratio of progeny was determined. The survival rate of females was also recorded.

Statistical analysis:

For the relation between the effect of different constant temperatures and developmental rates (1/ developmental times within the tested range), linear regression (Y = a ± bX) was used. Obtained data was analyzed using Proc Reg in SAS (Anonymous 2003). This way leads to calculate degree-day's constants of developmental threshold (t_0) and K value in degree-days DDs as physiological time. Life table parameters were estimated according to (Birch 1948) using the Life 48, BASIC Computer programmed (Abou-Setta et al. 1986).

RESULTS AND DISCUSSION

Development of *A. melongena* at three constant temperatures

Results showed that *A. melongena* male and females successfully developed on Magd eggplant cultivar at the three tested constant temperatures (20, 26, and 32°C). All immature stages developed faster as the temperature increase from 20 to 32°C. Developmental time was the longest at 20°C (14.43 days) and the shortest at 32°C (6.63 and 6.60 days) for respectively female and male). The shortest generation period was recorded at 32°C (8.63 days) and the longest one at 20°C (17.34 days) (Table 1).

The female pre-ovipostion and post-ovipostion periods were differed at the three tested temperatures. The shortest periods were 2.01 and 1.85 days at 32°C, and the longest ones (2.91 and 3.87 days) at 20°C. The longest oviposition period was 15.26 days at 32°C and the shortest one was 12.89 days at 20°C.

Mean fecundity and daily rates were increased as temperature increase. The maximum fecundity rate was 20.64 eggs/female and the daily rate was 1.36 eggs/female/day at 32°C, followed by 17.31 eggs/female and 1.24 eggs/female/day at 26°C. The lowest ones were 14.84 eggs/female and 1.16 eggs/female/day at 20°C. The total female and male longevity ranged between 18.02 and 19.68 days, wholly in agreement with the results obtained by Farahat (2020) who found that the life cycle of *A. melongena* took 15.94 days at 18°C, the female longevity at 18°C was 23.06 days and the fecundity was 28.45 eggs/female. On the other side, Baradaran and Daneshwar (1992) reported that development of *Aceria lycopersici*

Wolffenstein from egg to adult took eight days at 25°C and 50% R.H. Ansaloni and Perring (2014) found that the development of *Aceria guerreronis* Keifer (egg to adult) required 30.5, 16.0, 11.5, 8.1, and 6.8 days at 15, 20, 25, 30, and 35°C, respectively.

Abou-Awad et al. (2000) showed that the longevity of fig rust mite, *Rhyncaphytoptus ficifoliae* Keifer was 19.45 days for females at 29°C, which in agreement with the current study (19.11 days) at 32°C. Also, Bahirai et al. (2019) reported that the longevity of *R. ficifoliae* was 18.92 days at 30°C, and the total fecundity was 15.43 eggs/female at 25°C.

Thermal requirements of *A. melongena*

Correlation coefficient associated with the developments of egg, larva, nymphal stages (R^2) were respectively 0.972, 0.98, and 0.97 on Magd eggplant cultivar (Table 2). Results indicated that the linear model described the influence of temperature on the developmental rate of *A. melongena* within the tested range. The lowest thermal threshold (t_0) for egg, larva, nymph, and life cycle were respectively 14.47, 5.36, 5.96, and 9.87°C. The thermal constant (K) for completion of the mentioned stages were respectively 36.03, 72.42, 49.68, and 148.83 degree-days. The lowest developmental threshold temperature (14.47°C) for egg and its thermal constant (26.32) degree-days was almost the lowest as compared to all other stages (Table 2). The results showed that a threshold of 9.87°C and 148.83 accumulated degree-days were required for *A. melongena* to complete one generation on Magd eggplant cultivar. These results indicated that *A. melongena* remained active at a lower temperature and had a potential to develop over a wide range of temperatures.

The current results agree with findings of Farahat (2020) who showed that the lowest developmental threshold temperature (13.30°C) for egg and thermal constant (35.59) degree-days was almost the lowest compared to all other stages on Batra eggplant cultivar. Elhalawany and Abdel-Wahed (2013) showed also that R^2 values of *Tetranychus urticae* Koch ranged between 0.93 and 0.99 for egg, larva, and protonymph on Hachiya persimmon cultivar. The lowest thresholds (t_0) were 11.17, 7.64, and 6.63°C. The thermal constants (K) were 68.02, 56.49, and 61.34 degree-days, respectively.

Life table parameters

The most important parameters, T, r_m, and R_0 differed between the three constant temperatures (Table 3). The mean generation time (T) at 32°C was 12.64 days, and the longest one at 20°C was 20.08 days. The intrinsic rate of increase (r_m) value was the lowest at 20°C (0.097), followed by 26°C (0.149) and the highest value was 0.191 ♀/♀/day at 32°C. Similarly, net reproductive rate (R_0) value was the lowest at 20°C (7.10) and the highest was 11.25 ♀/♀ at 32°C. The shortest doubling time (DT) was 3.62 days at 32°C and the longest one was 7.14 days at 20°C. The gross reproductive rate (GRR) increased from 9.95 offspring/individuals at 20°C to 14.71 offspring/individuals at 32°C. The survival rate was 80, 84, and 85% at respectively 20, 26, and 32°C.

In the present work, the r_m and R_0 values of *A. melongena* fed on Magd eggplant cultivar were respectively 0.097 to 0.191 and 7.10 to 11.25. These values were much lower than the findings of Farahat (2020) when females reared on Betra eggplant cultivars (i.e., 0.106–0.214 and 17.63–30.92, respectively). Abou-Awad et al. (2000) showed that the r_m value for *Aceria ficus* Cotté was 0.19 females/female/day at 29°C, which in agreement with the current study at 32°C (i.e., 0.191 females/female/day). The mean generation time (T) (20.08 days) at 20°C is totally agrees with the finding for *A. ficus* (17.9 days) at 29°C.

CONCLUSION

The current work concluded that *A. melongena* shows fast growth rate and short generation time at higher temperature than at lower one. This indicated its capacity to facilitate the rapid spread and outbreak in warm regions. This study provided information on the life history which would be useful in planning control strategies for *A. melongena*.

Table 1. Mean developmental duration in days (±SD) of *Aceria melongena* stages reared on "Magd" eggplant leaves at three constant temperatures and 60% R.H.

Stages	Female			Male		
	20°C	26°C	32°C	20°C	26°C	32°C
Egg	5.90±0.39	3.48±0.37	1.99±0.15	5.88±0.37	3.44±0.31	1.92±0.09
Larva	5.12±0.59	3.35±0.37	2.77±0.30	5.29±0.51	3.27±0.40	2.80±0.37
Nymph	3.41±0.39	2.62±0.31	1.87±0.15	3.25±0.41	2.53±0.28	1.88±0.14
Life cycle	14.43±0.71	9.45±0.56	6.63±0.38	14.43±0.79	9.24±0.44	6.60±0.39
Generation	17.34±0.71	11.88±0.69	8.63±0.39	–	–	–
Pre-ovipostion	2.91±0.15	2.43±0.27	2.01±0.13	–	–	–
Ovipostion	12.89±0.76	14.07±1.11	15.26±0.85	–	–	–
Post-ovipostion	3.87±0.29	2.37±0.42	1.85±0.20	–	–	–
Longevity	19.68±0.88	18.88±0.09	19.11±0.93	18.99±0.69	18.33±3.35	18.02±0.72
Fecundity (eggs/♀)	14.84±1.35	17.31±2.41	20.64±1.69	–	–	–
Daily rate (eggs/♀/day)	1.16±0.13	1.24±0.24	1.36±0.16	–	–	–
Life span	34.11±1.06	28.33±1.11	25.74±1.01	33.42±1.04	27.57±3.35	24.62±0.83

Table 2. Linear regression analysis values for the effect of temperature on *Aceria melongena* female developmental rate

Parameters	a	b	t_0	K	R^2
Egg	-0.402	0.028	14.477	36.034	0.972
Larva	-0.074	0.014	5.364	72.421	0.980
Nymph	-0.120	0.020	5.964	49.689	0.977
Life cycle	-0.066	0.007	9.874	148.837	0.997

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

Table 3. Life table parameters of *Aceria melongena* female reared on eggplant leaves at three constant temperatures and 60% R.H.

Parameter	20°C	26°C	32°C
Gross reproductive rate (GRR)[d]	9.95	12.24	14.71
Sex ratio (♀♀/total)	0.6	0.6	0.65
Net reproductive rate (R_0)b	7.1	9.56	11.25
Survival rate %	80.00	0.85	0.84
50% mortality a	26	22	22
Mean generation time (T)a	20.08	15.07	12.64
Intrinsic rate of increase (r_m)c	0.097	0.149	0.191
Finite rate of increase (λ)[C]	1.1	1.16	1.21
Doubling time (DT)a	7.14	4.65	3.62

[a]Days, [b]♀/♀,[c]♀/♀/day, d offspring/individual, $R_0 = \Sigma(l_x \times m_x)$; $T_c = \Sigma(x \times l_x \times m_x) / \Sigma(l_x \times m_x)$; $r_m = \ln(R_0)/T$; $DT = \ln(2)/r_m$, $\lambda = \exp(r_m)$ and GRR= Σmx.

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