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Effect of Temperature on Biology of *Oligonychus mangiferus* (Rahman and Sapra) (Acari: Tetranychidae)

Abu-shosha, M. A.[1]; A. A. Abdallah[2]; N. M. Abdel-Aziz[1] and A. S. Mahmoud[1]
[1]Agric. Zoology and Nematology Dept., Faculty of Agriculture, Al-Azhar University branch Assiut.
[2]Agric. Zoology and Nematology Dept., Faculty of Agriculture, Al-Azhar University.

ABSTRACT

Life history and reproductive parameters of the mango red spider mite, *Oligonychus mangiferus* (Rahman and Sapra) (Acari: Tetranychidae) were studied to investigate its response to different temperatures (25, 28 and 31 ºC), with 70 ± 5% R.H. on *Mangifera indica* L. Baladi variety in the laboratory. The results showed that the developmental time of the individuals shortened with increasing temperature. The total immature stages was the longest period (7.51 day for the female and 7.46 day for the male) at 25 ºC, while at 31°C was the shortest period (6.48 and 6.46 day, respectively). The life cycle was the longest period (12.18 day for the female and 11.71 day for the male) at 25 ºC, while at 31°C was the shortest period (10.78 and 10.38 day, respectively). So, the mean generation time was the longest (20.12 days) at 25 °C, followed by 28 °C (19.06 days) and then at 31°C was the shortest (17.87 days). On the contrary, total fecundity was 32.50 eggs (2.05 eggs/♀/day) at 25 ºC, then at 28 °C it reached 30.17 eggs (2.01 eggs/♀/day) and 26.83 eggs (1.93 eggs/♀/day) at 31°C, respectively. The mean generation time recorded the shortest (17.87 days) at 31°C, while the fecundity recorded the highest rate at 25 ºC (32.50 eggs; 2.05 eggs/♀/day). Based on these results, we can predict the presence of *O. mangiferus* on mango. Therefore, it should be easily to determine the best time to control this pest.

Keywords: Life history, life cycle, spider mite, *Oligonychus mangiferus,* generation time, and fecundity.

INTRODUCTION

The mango red spider mite, *Oligonychus mangiferus* (Rahman and Sapra), is a serious mango pest, that is widely distributed in many countries, including Egypt, China, Hawaii, India, Israel, Mozambique, Myanmar, Pakistan, Peru, Singapore, Taiwan, and Thailand (Jeppson *et al*. 1975; Waterhouse 1993; Wate 2002). In Egypt, *O. mangiferus* is a pest of cotton and considered as the second serious pest on pomegranate (Moutia 1958; Mohamed 1963). In recent years, its population increased rapidly on mango trees, especially the nurseries. It is a pest attacking peach, pear, litchi, loquat, grape and sweetsop (Migeon and Dorkeld 2017). *Oligonychus mangiferus* can also infest different varieties of mango feeding on the upper leaf surface, destroying leaf cells, and forming pale patches on leaves. The mite population rapidly increases to a high density especially in dry seasons. Feeding causes the mango leaves to turn pale, greatly influencing the photosynthesis of the mango tree producing a drying effect and premature leaf drop and indirectly reducing the quality and quantity of mango fruits, (Al-Azzazy 2005; Ming-Ying Lin 2013).

MATERIALS AND METHODS

A - Source of phytophagous mite:

Oligonychus mangiferus was collected from leaves of mango trees at the farm of faculty of Agriculture, Al – Azhar University, Assuit branch as mobile individuals.

B – Rearing of *Oligonychus mangiferus* mite:

Mite culture: stock culture of mites was established by placing a copulated female together on mango leaf (*Mangifera indica*) situated upside down on cotton wool soaked in water in 9 cm diameter Petri–dish and left to deposit eggs. The edges of the leaf were lined with a wet cotton barrier until we get high numbers of *O. mangiferus*.

The float leaf method was used to rear *O. mangiferus* during the life history study. Circularly mango leaf disc (2.5 cm in diameter) was cut from El-Baladi mango leave and a disc was placed with the upper surface face-up in a Petri dish (10 cm diameter) situated on cotton wool soaked in water. Float leaf discs were replaced every 4 days.

C- Life history observations

Forty mites females from the stock population were introduced into a float leaf and allowed to lay eggs. The adults were then removed from the float leaf, leaving only one egg on the foliar disc. Examining for eggs were every 12 h, until larvae hatched. The sex of the mite can be distinguished in the late deutonymphal stage. Each Deutonymph stage of female was provided with numbers of adult males from the stock colony for mating. Checking of Petri dishes were for the producing of eggs every day after the deutonymph females transformed to adult stage, and the eggs were removed. Each male deutonymph was provided with an adult female from the stock colony to observe the adult male longevity. All experiments were kept at 25, 28, and 31 OC and 70 ± 5 % R.H. The developmental time of each stage, longevity, preoviposition, oviposition periods and fecundity of females were computed from the observed data.

Statistical analysis of data:

F. test and L.S.D. values used for comparison between means of the treatments of the biology of *O. mangiferus* with different temperatures.

Life table parameters

O. mangiferus life tables were calculated with the aid of a computer program of Abou-Setta *et al*., (1986). The doubling time of a population (DT)= by equation Dent and Walton (1997)

$$\text{The doubling time of a population (DT)} = \frac{\log 2}{rm}$$

RESULTS AND DISCUSSION

Biology of *Oligonychus mangiferus* :

The mango red mite, *Oligonychus mangiferus* was reared at 25, 28 and 31˚C and 70 ± 5 % R.H. on mango leaves Baladi variety, which are presented in the following:-

I-Developmental period (life cycle):-

Data presented in table (1) showed that the average female´s incubation period of O. mangiferus was decreased when temperature increased, as it was 4.67, 4.44 and 4.31 days at 25, 28 and 31˚C, respectively, The differences were significant between 25 and 31°C . For male, it averaged 4.25, 4.17 and 3.92 days at the same temperature degrees, respectively, The differences were not significant between 25 and 28°C, while it was significant between at 31 with 25 or 28°C.

Table 1. Duration (days ± S.D) of *Oligonychus mangiferus* reared on mango (Baladi variety) at constant temperatures and relative humidity 70 ± 5 %

Stages	Sex	Temperatures (°C)			LSD 5%	LSD 1%
		25 °C	28 °C	31°C		
Incubation Period	♀	4.67 ± 0.34 B	4.44 ± 0.42 AB	4.30 ± 0.30 A	0.24	0.32
	♂	4.25 ± 0.26 B	4.17 ± 0.25 B	3.92 ± 0.29 A	0.22	0.30
Larva	♀	2.53 ± 0.27	2.39 ± 0.40	2.17 ± 0.24	-	-
	♂	2.54 ± 0.26	2.29 ± 0.33	2.17 ± 0.25	-	-
Proto- nymph	♀	2.42 ± 0.26	2.31 ± 0.35	2.14 ± 0.23	-	-
	♂	2.42 ± 0.51	2.21 ± 0.26	2.08 ± 0.19	-	-
Deuto- nymph	♀	2.56 ± 0.29	2.33 ± 0.20	2.17 ± 0.24	-	-
	♂	2.50 ± 0.30	2.33 ± 0.33	2.21 ± 0.26	-	-
Total Immatures	♀	7.51 ± 0.38 C	7.03 ± 0.40 B	6.48 ± 0.32 A	0.24	0.32
	♂	7.46 ± 0.58 C	6.83 ± 0.39 B	6.46 ± 0.26 A	0.36	0.48
life cycle	♀	12.18 ± 0.48 C	11.47 ± 0.44 B	10.78 ± 0.46 A	0.29	0.39
	♂	11.71 ± 0.62 C	11.00 ± 0.37 B	10.38 ± 0.31 A	0.38	0.51

The duration of the developmental stages of *O. mangiferus* immature stages increased when the temperature decreased. Data in table (1) illustrated that the duration of female larval stages averaged 2.53, 2.39 and 2.17 days; protonymph averaged 2.42, 2.31 and 2.14 days and deutonymph averaged 2.56, 2.33 and 2.17 days at 25, 28 and 31˚C, respectively.

The female developmental time (life cycle) of *O. mangiferus* averaged 12.18, 11.47 and 10.78 days at temperatures of 25, 28 and 31˚C, respectively. The differences were significant between 25 and 31°C. Male followed similar trend of female, but having often shorter periods. The male larval stage average 2.54, 2.29 and 2.17 days; protonymph average 2.42, 2.21 and 2.08 days while, deutonymph lasted 2.50, 2.33 and 2.21 days at 25, 28 and 31˚C, respectively, the differences were significant between the three temperatures studied.

This study indicated that the development of *O. mangiferus* increased as increasing temperature. Fu and Zhang (2002), Abou- Awad *et al*. (2011) and Ming-Ying Lin (2013) also studied the biological parameters of *O. mangiferus* at various temperatures, and showed a similar tendency, although, Fu and Zhang (2002) reported a shorter developmental time, while Abou-Awad *et al.* (2011) obtained a longer development at 15 ºC but it was shorter at 23 and 31 ºC. Difference in relative humidities from 65 to 75 % may explain the differences in development time(Abou-Awad *et al*., 2011).

The developmental time of each stage of *O. mangiferus* is generally shorter for males than females (Abou-Awad *et al*. 2011; Ming-Ying Lin 2013; Rai *et al.* 1988). The same results are true for *O. perseae* (Aponte and McMurtry 1997) and *O. coffeae* (Gotoh and Nagata 2001). In the present study such a difference between the sexes was not clear. The developmental time of males was shorter than that of females, and males have a shorter incubation period under all tested postembryonic immature stages, consequently their entire immature development period was shorter than that of females, but this difference was not statistically significant.

II: Reproduction and life table parameters:-

The used temperatures obviously affected adult female longevity (Table 2), Maximum female longevity was obtained at 25˚C, while the minimum period was recorded at 31˚C. Female longevity averaged 22.78, 20.85 and 18.86 days at 25, 28 and 31˚C, respectively. The pre-oviposition period was 0.86, 0.69 and 0.53 days; while the oviposition period averaged 15.89, 14.83 and 13.89 days; and the post-oviposition period averaged 6.03, 5.33 and 4.44 at 25, 28 and 31˚C, respectively. High significant differences were found in the oviposition and post-oviposition phases between the three tested temperatures, while no significant differences were found in pre-oviposition duration between 28 and 31 ˚C but it was significant differences for 25 ˚C.

The total and daily rate female fecundity averaged 32.50, 2.05 & 30.17, 2.03 and 26.83, 1.93 eggs/day at 25, 28 and 31˚C, respectively. The life span for female averaged 34.96, 32.32 and 29.64 at 25, 28 and 31˚C, respectively, while it averaged 32.46, 31.00 and 29.05 at 25, 28 and 31˚C for male, respectively. The differences were statistically significant between the three temperatures studied, (Table 2).

Longevity period of spider mite decreases as increasing of temperature (Zaher and Shehata 1971; Fu and Zhang 2002; Abou-Awad *et al.* 2011; Ming-Ying Lin 2013). The longevity of *O. mangiferus* recorded in this study resembles that of Zaher and Shehata (1971), Fu and Zhang (2002) and Ming-Ying Lin (2013) while Nangia *et al.* (1989) and Abou-Awad *et al*. (2011) found that *O. mangiferus* lived considerably longer.

Table 2. Duration (days ± S.D) of *Oligonychus mangiferus* reared on mango (Baladi variety) at constant temperature and relative humidity 70 % ± 5 %

Stages	Sex	Temperatures (°C)			LSD 5%	LSD 1%
		25 °C	28 °C	31°C		
Pre-oviposition	♀	0.86 ± 0.23 B	0.69 ± 0.25 A	0.53 ± 0.12 A	0.14	0.19
Oviposition	♀	15.89 ± 1.17 C	14.83 ± 1.58 B	13.89 ± 1.18 A	0.14	0.19
Post-oviposition	♀	6.03 ± 1.12 C	5.33 ± 0.45 B	4.44 ± 0.48 A	0.50	0.67
Total average of eggs	♀	32.50 ± 2.01 C	30.17 ± 3.01 B	26.83 ± 4.55 A	2.25	3.00
Daily rate	♀	2.05	2.03	1.93	-	-
Longevity	♀	22.78 ± 1.96 C	20.85 ± 1.73 B	18.86 ± 1.01 A	1.08	1.44
	♂	21.75 ± 1.29 C	20.00 ± 1.28 B	18.67 ± 1.15 A	1.03	1.39
Life span	♀	34.96 ± 1.80 C	32.32 ± 1.64 B	29.64 ± 1.21 A	1.05	1.40
	♂	32.46 ± 1.37 C	31.00 ± 1.33 B	29.05 ± 1.20 A	1.08	1.45

Table (3) showed that the net reproductive rate (*R0*) decreased when temperature increased. These values were 27.59, 27.21 and 23.88 eggs population/ female at 25, 28 and 31 ˚C, respectively. The intrinsic rate of increase (*rm*) was increased as the temperatures increased where it reached 0.165, 0.173 and 0.178 eggs/♀/day; as well as the corresponding values of finite rate of increase (erm) were 1,179, 1.189 and 1.194 at 25, 28 and 31 ˚C, respectively. The mean generation time (T) was 20.12, 19.06 and 17.87 days, while the gross reproduction rate (GRR) was 32.39, 30.01 and 26.72 at 25, 28 and 31 ˚C, respectively. The percentage 50% mortality decreased when temperature increased where it averaged 33.50, 32.00 and 29.50 days at 25, 28 and 31˚C, respectively. Mites needed to an average of 4.20, 4.00 and 3.89 at 25, 28 and 31 ˚C to double their numbers, respectively.

The highest *rm* values of *O. mangiferus* in the present study and that of Ming-Ying Lin (2013) Fu and Zhang (2002) and Abou-Awad *et al*. (2011) averaged 0.178, 0.182, 0.396 and 0.125, when the temperature was 31, 29, 28, 31 °C, respectively. On the other hand, Wrensch (1985) found that the highest *rm* values of various *Tetranychus* species ranged from 0.355 to 0.46. Saito (1979) reported that *Panonychus* species living on woody plants, would have a lower *rm* values than *Tetranychus* spp. Also, Sabelis (1985) accepted Saito's observations concerning other genera of tetranychid mites including *Oligonychus*. Nevertheless, *O. perseae* and *O. coffeae* are two species morphologically similar to *O. mangiferus*. The biological parameters of these species were carefully investigated by Aponte and McMurtry (1997) and Gotoh and Nagata (2001). Compared to this study, they observed a similar developmental period, slightly longer longevity, and a higher fecundity. However, the highest *rm* values of these two species were 0.215 and 0.144, respectively, both at 30 °C. Thus, the higher *rm* of *O. mangiferus* observed by Fu and Zhang (2002) is probably uncommon. There are many factors could affect the performance of *O. mangiferus* and cause this variation. These factors include experimental conditions, method of handling during the study, food type, and importantly, mite strain, which will have adapted to the local climate and host plant varieties. this variation highlights the exigency of conducting a life history study on local strains to obtain population parameters suitable for the application to local agricultural systems.

Table 3. Effect of temperatures on the life table parameters of the red spider mite *Oligonychus mangiferus* reared on mango (Baladi)

Population parameters	Temperature (°C)		
	25 °C	28 °C	31°C
Net reproductive rate (R_0)	27.59	27.21	23.88
Intrinsic rate of increases (r_m)	0.165	0.173	0.178
Finite rate of increase (e^{rm})	1.179	1.189	1.194
Mean generation time GT (day)	20.12	19.06	17.87
Gross reproduction rate (GRR)	32.39	30.01	26.72
50% mortality (days)	33.50	32.00	29.50
The doubling time of a population	4.20	4.00	3.89

Figure (1) Explains in detail the capability of reproductive of *O. mangiferus* females on mango Baladi variety at different temperatures, age-specific survival rate (Lx), age-specific fecundity (Mx), and age-specific maternity (LxMx) = Net reproductive rate (*R0*). It is noted that egg-laying began early as the temperature increased, on day 13, 12 and 11 after eggs were laid, at 25, 28 and 31 °C respectively.

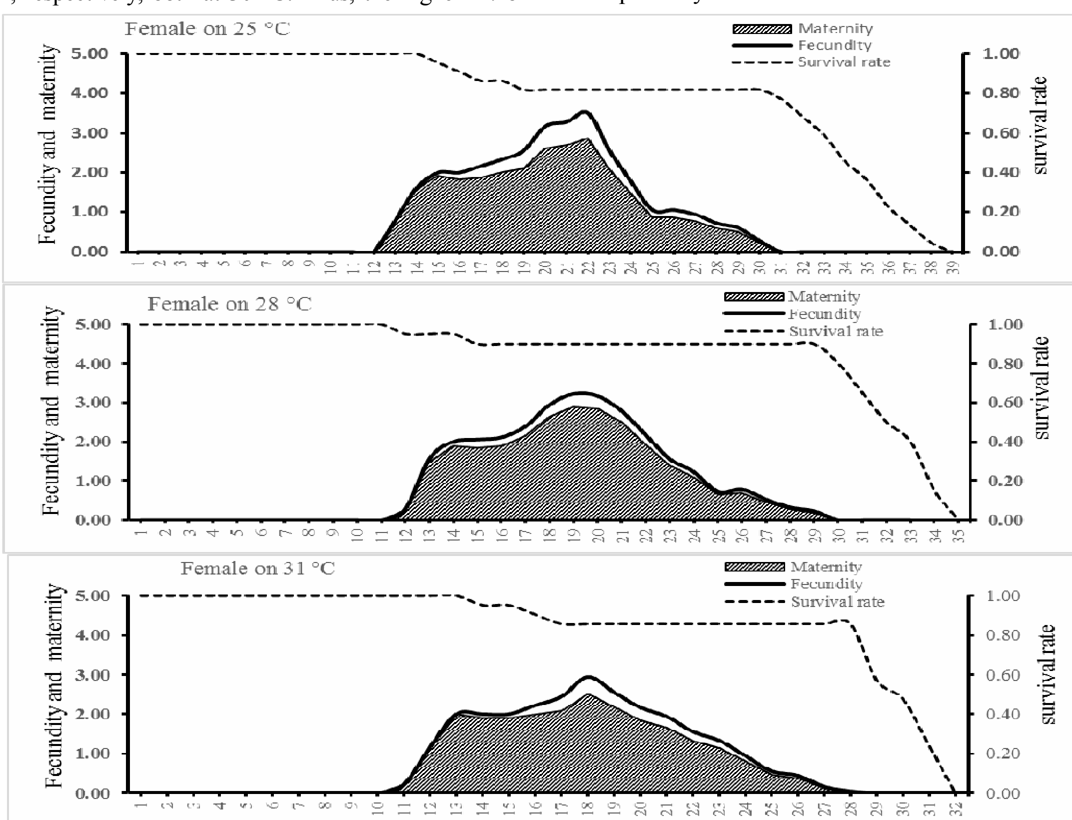

Fig. 1. Age-specific survival rate (Lx, choppy line), fecundity (Mx, bold line) and maternity (LxMx, Shaded area) of *Oligonychus mangiferus*

It was gradually delayed as the temperature decreased. Life time oviposition was skewed left, because females laid high number of eggs at the initial period and subsequently exhibited lower fecundity. Interestingly, the daily egg-laying rate was gradually increasing and its peak in day 22nd, 19th and 18th with 3.50, 3.22 and 2.94 eggs, at 25, 28 and 31 °C, respectively. After the founding eggs were laid, then began gradually decreasing with age increase until egg laying stopped. The results agree with these obtained by Ming-Ying Lin (2013).

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تـأثير درجـات الحـرارة علـى بيولـوجي الأكـاروس ***Oligonychus mangiferus*** **Rahman and Sapra (Acari: Tetranychidae)**

محمد أبو الحمد عبدالمقصود أبو شوشة[1], عوض على عبدالله[2], نشأت عبد العزيز محمود [1] و أحمد شرف محمود محمد [1]

[1] قسم الحيوان الزراعى و النيماتودا – كلية الزراعة – جامعة الأزهر- فرع أسيوط

[2] قسم الحيوان الزراعى و النيماتودا – كلية الزراعة – جامعة الأزهر – القاهرة

تهدف هذه الدراسه الى معرفة تـأثير درجـات الحـرارة (25 و28 و31°م) والرطوبـة النسبية 70 ± 5% علـى تـاريخ حياة أكـاروس المـانجو الأحمر *Oligonychus mangiferus* على اوراق المانجو البلدى فى المعمل. وقد أسفرت نتائج التجربة الى سرعة تطور أفراد الآفة بزيادة درجة الحرارة، حيث كانت أطول فترة للأطوار غير البالغة 7.51 يوم للإنـاث و7.46 يوم للذكور عند درجـة حـرارة 25°م، بينما كانت عند درجـة حـرارة 31°م 6.48 و6.46 يـوم للإنـاث والذكور علـى التوالى. واستغرقت دورة حياة الأكاروس العنكبوتى أطول فترة عند درجة حرارة 25°م حيث كانت 12.18 يوم للإناث و11.71 يوم للذكور، بينما كانت عند درجة حرارة 31°م سجلت أقصر فترة 10.78 و10.38 يوم للإناث والذكور على التوالى. وقد سجل متوسط الجيل أطول فترة عند درجة حرارة 25°م حيث كانت 20.12 يوم، تليها عند درجة حرارة 28°م حيث كانت 19.06يوم، ثم بعد ذلك وصلت أقصر فترة للجيل الى17.87 يوم عند درجة حرارة 31°م. وعلى النقيض، قد سجلت الإناث عند درجة حرارة 25°م أعلى كمية لوضع البيض (الخصوبة) 32.50 بيضة، بمعدل 2.05 بيضة/♀/يوم، تليها عند درجة حرارة 28°م كانت30.17 بيضة، بمعدل 2.01 بيضة/♀/يوم، ثم بعد ذلك اعطت الإناث أقل كمية لوضع البيض26.83 بيضة، بمعدل 1.93 بيضة/♀/يوم، عند درجة حرارة 31°م. وقد سجلت النتائج أقصر فترة لمتوسط الجيل 17.87 يوم عند درجة حرارة 31°م وأعلى معدل للخصوبة 32.50 بيضة/أنثى عند درجة حرارة 25°م وإستناداً إلى هذه النتائج، يمكننا التنبؤ بوجود مراحل مختلفة من *O. mangiferus* على المانجو مع مرور الوقت. وبالتالي فإن هذه المعلومات تمكننا من الدقة فى تحديد الوقت المناسب للسيطرة على هذه الآفة.