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Temperature Effect and Biological Aspects of *Phenacoccus parvus* Morrison (Hemiptera: Pseudococcidae).

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ABSTRACT

The present study was carried out under laboratory conditions to investigate the influence of four constant temperatures (20, 25, 30 and 35ºC) and 60±5% R.H.on the development of the immature stages of *Phenacoccus parvus* Morrison as well as on the reproductive potential of the adult, and to estimate the relation between thermal units required for the development and degree-days (DD's). The incubation period lasted 6.6 ± 0.22, 5.8 ± 0.13, 4.2 ± 0.20 and 3.2± 0.13 days for eggs at constant temperatures 20, 25, 30 and 35ºC, respectively. The developmental period of nymphal stage tended to be shortened with the corresponding increments of temperature. At a specific temperature, the developmental period of the nymphal stage was 25± 0.09, 22.5± 0.06, 17.1± 0.12 and 13.7± 0.09 days at 20, 25, 30 and 35ºC, respectively. The calculated developmental thresholds (t_0) of the egg and nymphal stages were found to be 7.58 and 3.72ºC, respectively; meanwhile, the calculated developmental threshold of the whole immature stages was estimated as 5.71 and 5.76ºC for male and female, respectively. The mean thermal units required for development of *P. parvus* eggs and nymphal stages were 469.80, 134.88 DD's degree-days, respectively.

Keywords: *Phenacoccus parvus*, biology, thermal units, degree-day.

INTRODUCTION

The lantana mealybug, *Phenacoccus parvus* Morrison (Hemiptera : Pseudococcidae) has been recorded recently for the first time in Egypt infesting *Hibiscus* sp. (Abd-Rabou *et al*., 2010). It was recorded on approximately 50 plant species, belonging to twenty six families (Ben-Dove *et al.* 2005). It is a pest of economic importance (Marohasy 1997; and Sridhar *et al*. 2012) on solanaceous crops, and in case of intensive infestation, complete mortality of young plants and seedlings was recorded (Firake *et al*. 2016).

Ibrahim *et al*. (2015), reported that great populations of invasive mealybug cause general weakening, defoliation and death of susceptible plants by sucking sap from plants, and by acting as plant diseases agents vectors, and honeydew deposition causes growth of sooty moulds.

Biological events of the insect in relation to key environmental factors are necessary to determine the extent of their influence on the population dynamic of the pest. Temperature is a remarkable environmental factor affecting the rate of development, fecundity and the survival of an insect within a given environment (Lu *et al.,* 2011). Studding this parameter is particularly interesting for economically important insects to attain a useful information for good forecasting and prediction system of insect population (Attia *et al.,* 2015, Shehata, 2017). Heat unit systems quantify the thermal environment of organisms (Paul, 2013).

Therefore, the study carried out to estimate the effect of four constant temperatures on the development of the different stages of *Phenacoccus parvus* as well as on the adult reproductive potential, and to calculate the mean thermal units (degree-days) required for development of *this pest*.

MATERIALS AND METHODS

1. Insect source:

To have a culture of lantana mealybug, *Phenacoccus parvus* Morrison (Hemiptera: Pseudococcidae), gravid females were collected from infested ornamental plant, *Lantana camara* and reared on sprouting potato tubers under laboratory condations . In laboratory Plant Protection Research Institute El Mansoura 2015-2016. The collected mealybug was identified at Scale Insects and Mealybug Research Department, Plant Protection Research Institute, Agric. Res. Center, Giza, Egypt.

2. Influence of temperature on the development of the immature stages:

The developmental period and the mean thermal units required for development of each stage of *P. parvus* were estimated at four different constant temperatures (20, 25, 30 and 35 ºC ±1ºC) and 60±5% R.H.

The effect of temperature was estimated on the different developmental stages of *P. parvus*, newly laid eggs (obtained from the stock culture) were placed separately in plastic tubes (4 cm length – 4 cm diameter) . Each tubes contains 10 eggs on small sprouted potato. All the tubes containing the eggs were incubated. Five replicates for each treatment were investigated and the incubation period was calculated under each constant temperature. The newly hatched crawlers of *P. parvus* were reared on sprouted potato in a carton cylindrical box (8 cm long and 12 cm diameter) at the same constant temperature till adult emergence. The boxes were inspected daily till the emergence of *P. parvus* adults, and the duration of each developmental stage was recorded.

Statistical analyses using analysis of variance and means of duration for all collected data were compared by using L.S.D. values.

3. Influence of temperature on the adult stage:

The effect of temperature on the adult stage was estimated, the emerging adults were reared on sprouted potato inside the boxes and allowed to reproduce at the previously mentioned constant temperatures (20, 25, 30 and 35°C ±1ºC). The boxes were inspected daily, and the duration of pre-oviposition, oviposition and post- oviposition periods, fecundity and the longevity of female were recorded as well as male longevity.

4. Estimate the thermal units required for *P. parvus* development:

To determine the development threshold of each instar or stage, linear regression method was used according to the following:

The points obtained when the reciprocal for time (1/y) in days are plotted against temperature (t) in degree centigrade, each of the reciprocals is multiplied by 100, so that the values on the ordinate (100/y) represent the average percentage development made by the stage per day, at the given temperature. Therefore, the distribution of the points indicates the course of temperature velocity curve (Davidson, 1944).

Theoretically, the point which the velocity line crosses the temperature axis is the threshold of development in degree centigrade (t_0).

Thermal units required for complete development of each stage was determined according to the equation of thermal summation (Blunk, 1923) .The degree-days (DD's) were calculated from the following equation:

$$K = y\ (t - t_0)$$

Where:

K : thermal units (day-degree).
y: the developmental duration of a given developmental stage.
t : temperature in degree centigrade °C.
t_0: temperature threshold of development in degree centigrade.

RESULTS AND DISCUSSION

1- Influence of temperature on the adult stages of *Phenacoccus parvus* development:

The influence of different constant temperature on the duration of the developmental stages of *P. parvus* as well as on the reproductive potential of the adult female was estimated.

Egg stage:

The influence of different constant temperature on the incubation period was recorded in table (1). The incubation periods were 6.6 ± 0.22, 5.8 ± 0.13 , 4.2 ± 0.20 and 3.2 days at 20, 25, 30 and 35˚C respectively. A negative relationship between temperature and embryonic developmental period was recorded and at different constant temperatures significant differences between the incubation periods were observed. The longest incubation period (6.6 ± 0.22 days) was obtained at 20˚C and the shortest one (3.2 ± 0.13 days) was recorded at and 35˚C .

The present study reveals that 35˚C was the most suitable for egg duration (relatively shorter incubation period), meanwhile, the longest time was observed at 20°C. Similar trend was obtained by Firake *et al*. (2016) who found that the longest incubation period (6.5±0.33 days) of *P.parvus* eggs was recorded at 24±1˚C. This was also true for the mealybug *Phenacoccus solenapsis* eggs (Arif *et al*., 2012) who reported generally that high temperature was the optimum for the egg development.

Table 1. Duration of the immature stages (in days) of the *Phenacoccus parvus* at different constant temperature:

Temp (°C)	Egg stage	Duration of immature stage (in days) ± SD				
		Nymphal instars			Nymphal stage	Whole immature stages
		1st instar	2nd instar	3rd instar		
20	6.6± .22 a	8.3±0 .26a	8.5±0.40a	8.2± 0.25a	25.0 ± 0.09	31.6
25	5.8± 0.13b	7.4± 0.34b	7.6±0.31b	7.5±0.56a	22.5± 0.06	28.3
30	4.2± 0.20c	5.7± 0.21c	5.9± 0.18c	5.5± 0.17b	17.1± 0.12	21.3
35	3.2± 0.13d	4.6± 0.16d	4.7±0.15d	4.4± 0.16c	13.7± 0.0	16.9
L.S.D	0.505	0.725	0.798	0.725	2.78	1.23

Nymphal stage:

Data in Table (1) indicate that nymphal duration tended to be shortenend with the corresponding raise of temperature. Under any of the tested temperatures, the duration of the nymphal stage of *P. parvus* as a whole varied greatly. At a given temperature, the time requaired for the development of the nymphal stage was 25± 0.09, 22.5± 0.06, 17.1± 0.12 and 13.7± 0.09 days at 20, 25, 30 and 35°C, respectively. Statistical analysis showed that the longest time for the nymphal development was recorded at 20°C and the shortest period was noticed at 35°C. it's clear that the duration of the different nymphal instars were nearly similar affected by temperature. Significant differences were found between the mean durations of the nymphal stage reared at the different constant temperatures.

Concerning the influence of constant temperature on the development of nymphal stage of *P. parvus*, the duration of the nymphal stage decreased as the corresponding temperature raised from 20°C to 35°C. The obtained results are in agreement with Hameed *et.al* (2012) who reported that the total nymphal duration of the mealybug, *P. solenapsis* male and female decreased to about half times at 20°C to 40°C, respectively. Similar results was obtained by Amjad *et al.*(2012) that duration of 1st instar of *P. solenapsis* was 7-9 days at 25°C . Aheer *et al*. (2009) also reported that third instar female completed its life in 6.5 to 8.0 days at 25°C.

Adult stage:

The longevity of adult male was affected by the variation in temperature ; showing the longest period (2.5 ±0.17days) at the lowest temperature (20°C) and the shortest period (1.3 ±0.15days) at the highest one (35 °C) Table(2).

Generally, a negative relation between temperature and the developmental period of *P. parvus* males.. As temperature increases the developmental period decreases. Nearly, the same trend was recorded by Firake *et al.,* (2016) and Shehata (2017). Prishanthini and Vinobaba (2013) found that longevity of *P. solenapsis* males ranged from 1 to 2 days with an average of 1.5±0.5 days.

As shown in Table (2), adult female longevity at each temperature was divided into pre-oviposition, oviposition and post-ovipostion periods.. In general, the adult longevity for *P. parvus* females reduced on increasing temperature from 37.6 days at 20 °C to 20.0 days at 35°C.The pre-oviposition period was negatively affected by temperatures. The longest pre- oviposition period (8.4± 0.16 days) was observed at 20°C while, the shortest (4.5±0.17 days) at 35 °C. Firake *etal.*(2016) found that the female longevity ranged between 15.80 and 18.20 days on different host plants, and at 35±2°C, the pre-oviposition period of *P. solenapsis* lasted 6.7 days (Al-Obaidy *et al* , 2017)

The oviposition period seems to be much affected by temperatures, and varied according to the prevailing temperature. The obtained means of the oviposition period were 18± 0.0, 16± 0.13 , 15± 0.18 and 9 ± 1.03days at 20, 25, 30 and 35 °C, respectively. It is clear that oviposition period decreased with the increase of corresponding temperature. Statistical analysis of the data proved significant differences between the oviposition periods and the different constant temperatures. These results are similar to those of Prishanthini and Vinobaba (2013) who reported that pre-oviposition, oviposition and post-oviposition periods of *P. solenopsis* were greatly affected by temperature.

As shown in Table (2) the average period of the adult female longevity decreased significantly with the increase of temperature. The adult female longevity averaged 37.60± 2.90, 34.40 ± 2.43, 29.10 ± 2.78 and 20.00 ± 1. 32 days at 20, 25, 30 and 35 ˚C, respectively. A negative relationship between *P. parvus* female longevity and tested temperature degrees was concluded.

Also, Al-Obaidy *et al,* (2017) and Shehata (2017) reported that the adult female longevity of *P. solenapsis* was shorter 30 °C than 20°C.

Table 2. Duration (in days) of the adult longevity and fecundity of the *Phenacoccus parvus* at different constant temperature :

Temp. °C	Adult longevity (duration in days ± SD)					Fecundity (egg/Female)
	Male	Female				
		Pre-oviposition	Oviposition	Post-oviposition	Longevity	
20	2.5 ± 0.17a	8.4 ± 0.16a	18.0 ± 0.0a	11.2 ± 0.13a	37.6 ± 2.90a	153.9 ± 2.55b
25	2 ± 0.21ab	7.9 ± 0.23a	16.0 ± 0.17b	10.5 ± 0.17b	34.4 ± 2.43b	162.0 ± 2.45b
30	1.6± 0.16bc	5.9± 0.23b	15.0 ± 0.18b	8.2 ± 0.25c	29.1 ± 2.78c	179.9 ± 2.24ab
35	1.3 ± 0.15c	4.5± 0.17c	9.0 ± 1.03c	7.9 ± 0.17d	20.0 ± 1.61c	192.5 ± 3,9a
L.S.D at 0.05	0.501	0.580	1.28	0.528	2.07	25.98

Influence of temperature on the fecundity of *Phenacoccus parvus* :

Data given in Table (2) and illustrated in Figure (1) show the total number of deposited eggs / female during its life cycle at different constant temperatures. The total number of deposited eggs per female during its life cycle ranged from 153.9 ± 2.55 eggs/ female at 20 °C to 192.5 ± 3, 9 eggs/ female at 35 °C. The data clearly indicate that the highest number of egg (192.5 ± 3.9) was obtained at 35 °C. There was an insignificant difference between the number of deposited eggs at 30 °C and those at 35°C. It could be concluded that the temperature range of 30 - 35 °C may be considered as the thermal optimum zone for egg laying activity.

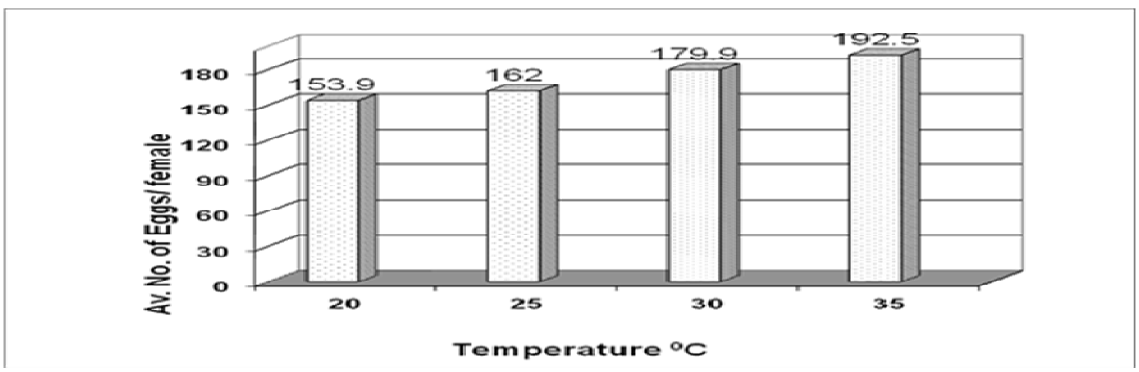

Fig. 1. Average number of *Phenacoccus parvus* females eggs reared at different constant temperatures (20, 25, 30 and 35 °C).

2- Developmental threshold (t_0) and thermal units (DDs) needed for the development of immature stages of *P. parvus*.

Data illustrated in Figure (2) show the relationship between the developmental rate (Table 3) of immature stages of *P. parvus* and different constant temperatures (20, 25, 30 and 35˚C). The temperature-velocity line data (Figure a, b c and d) for the embryonic development and nymphal stage as well as the whole immature stages for male and female were used to estimate the developmental thresholds.

The calculated developmental thresholds (t_0) for the egg stage (embryonic development) having the formula

y = 8.316 -1.0974X Figure (2).

So, the calculated developmental threshold (t_0) for the embryonic development was 7.58˚C (Table. 3). By using 7.58˚C as a base temperature, an average of 188.13, 300.32, 533.82 and 856.88 degree-days were calculated, respectively for the development of the egg stage at 20, 25, 30 and 35˚C with an average of 469.80 DD's. These results illustrate that the rate of development was slower at 20, 25 ˚C than at 30 ˚C and 35 ˚C. Thus, it's clear that the constant temperature from 20 ˚C to 35 ˚C is the optimum zone of effective temperature for the development of *P. parvus*.

Table 3. Developmental threshold (T_0) and thermal units (DDs) required for the development of immature stages of the lantana mealybug, *Phenacoccus parvus* reared at (20, 25, 30, 35 °C).

Stage	T_0	20 °C		25 °C		30 °C		35 °C		Mean Thermal units
		D.R. %	Thermal units DDs	D.R. %	Thermal units DDs	D.R. %	Thermal units DDs	D.R. %	Thermal units DDs	
Egg	7.58	15.15	188.16	17.24	300.32	23.81	533.82	31.25	856.88	469.80
Nymph	3.72	4	65.12	4.4	93.63	5.8	152.42	7.3	228.34	134.88
Total immature										
Male	5.71	2.47	35.30	2.76	53.24	3.80	92.30	4.76	139.42	80.06
Female	5.76	3.16	45.00	3.53	67.92	4.69	113.69	5.91	172.81	99.86

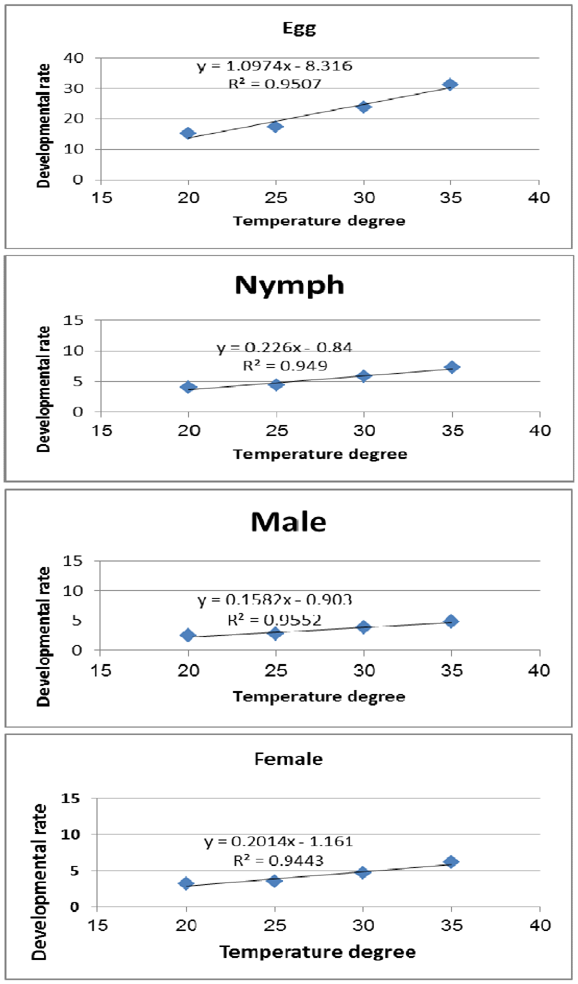

Fig. 2. The relationship between the developmental rate of *Phenacoccus parvus* immature stages (Eggs and Nymphal stage and total developmental time of adult male and female and different constant temperatures (20, 25, 30 and 35°C).

The estimated developmental thresholds (t_0) for nymphal stage of *P.parvus* were illustrated as in Figure (2), where its value reached 3.72 °C. The relation between the developmental rate of *P. parvus* and temperature degrees could be calculated by the following formula (Y = 0.84 - 0.226 X). By using these data as a base temperature, the mean values of thermal units required for nymphal development were 65.12, 93.63, 152.42 and 228.34 degree-days at 20, 25, 30 and35°C, respectively (Table, 3). With respect to the thermal summation equation (K = y (T – 3.72), the average of total thermal units was 134.88 degree-days.

With respect to the whole immature stages of *P. parvus* males, the calculated developmental threshold (t_0) was 5.71 °C. By using this data as a base temperature, the mean values of thermal units required for adult male development were 35.30, 53.24, 92.30 and 139.42 degree-days at 20, 25, 30 and 35 °respectively Figure (2). According to the thermal summation equation, the average of total thermal units was 80.06 degree-days.

With respect to the whole immature stages of *P. parvus* females, the calculated developmental threshold (t_0) was about 5.76 °C. By using this value as a base temperature, the mean values of thermal units required for adult male development were 45.00, 67.92, 113.69 and 172.81 degree-days at 20, 25, 30 and 35 °C, respectively Figure (2).According to the thermal summation equation, the average of total thermal units was 99.86 degree-days.

The present results clearly showed that temperature has a significant effect on the development of *P. parvus*. Developmental time decreased with increasing temperature to about 35 °C and then declined rapidly. The previous results supported the data of Amarasekare *et al*. (2008) who found that relatively higher temperature around 30°C is the optimum condition for the development of different stages of the mealybug, *Paracoccus marginatus* which required 303.0 DD's and 294.1 DD's to complete of the male and the female development , respectively. According to Kumer & Kontodimas (2012), *P.solenopsis* had slightly higher values of DD's (454.54 and 333.33 for the male and the female, respectively) to complete development from egg to adult emergence with a lower development threshold of 4.93 °C and 2.95 °C for female and male, respectively.. In addition, Chong *et al*. (2008) reported that value of thermal units was 347 DD's for the development of the females of *Maconellicoccus hirsutus*(Green).

Also, Shehata (2017) found that the thermal constant and developmental zero were calculated to be 7.29ºC and 79.9 DDs for eggs, 11.67ºC and 272.9 DDs for nymphal stages, 11.06ºC and 46.4 DDs for males and then 3.31ºC and 554.1 DDs for females, respectively. The duration of the life cycle was 65.6 ± 10.36 days at 20ºC; this was shortened to 35.51 ± 1.12 days at 30ºC. The thermal requirements to complete the insect development for one generation was 8.2ºC for the developmental zero and 774.1 DDs for the thermal constant.

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التأثيرات الحرارية والخصائص البيولوجية لبق اللانتانا الدقيقى *Phenacoccus parvus* Morrison (Hemiptera: Pseudococcidae)

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معهد بحوث وقاية النباتات – مركز البحوث الزراعية - الدقى – الجيزة- مصر

تمت دراسة تأثير درجات الحرارة (٢٠، ٢٥، ٣٠ ، ٣٥±١ °م ورطوبة ٦٠±٥٪) على بق اللانتانا الدقيقى وكذلك تقدير الاحتياجات الحرارية لنمو الحشرة تحت الظروف المعملية. وقد أوضحت النتائج أن فترة حضانة البيض بلغت ٦.٦ ± ٠.٢٢ و ٥.٨ ± ٠.١٣ و ٤.٢ ± ٠.٢٠ و ٣.٢ ± ٠.١٣ أيام على درجة حرارة ٢٠و ٢٥و٣٠ و٣٥ °م على التوالى . كانت فترة نمو طور الحورية ٢٥± ٠.٠٩ و ٢٢.٥ ±٠.٠٦ و ١٧.١ ±٠.١٢ و ١٣.٧ ±٠.٠٩ أيام على درجة حرارة ٢٠و ٢٥و٣٠ و٣٥ °م على التوالى . وقد اوضحت هذه الدراسة أن فترات النمو تقل مع زيادة درجات الحرارة . وقد بلغت قيمة صفر النمو البيولوجى للبيض والحوريات وجميع الأطوار غير الكاملة للذكر والأنثى ٧.٥٨ و ٣.٧٢ و ٥.٧١ و ٥.٧٦ °م على التوالى .كما بلغ متوسط الاحتياجات الحرارية لنمو الحشرة لكل من البيض والحوريات ٤٦٩.٨٠ و ١٣٤.٨٨ DD's على التوالى.