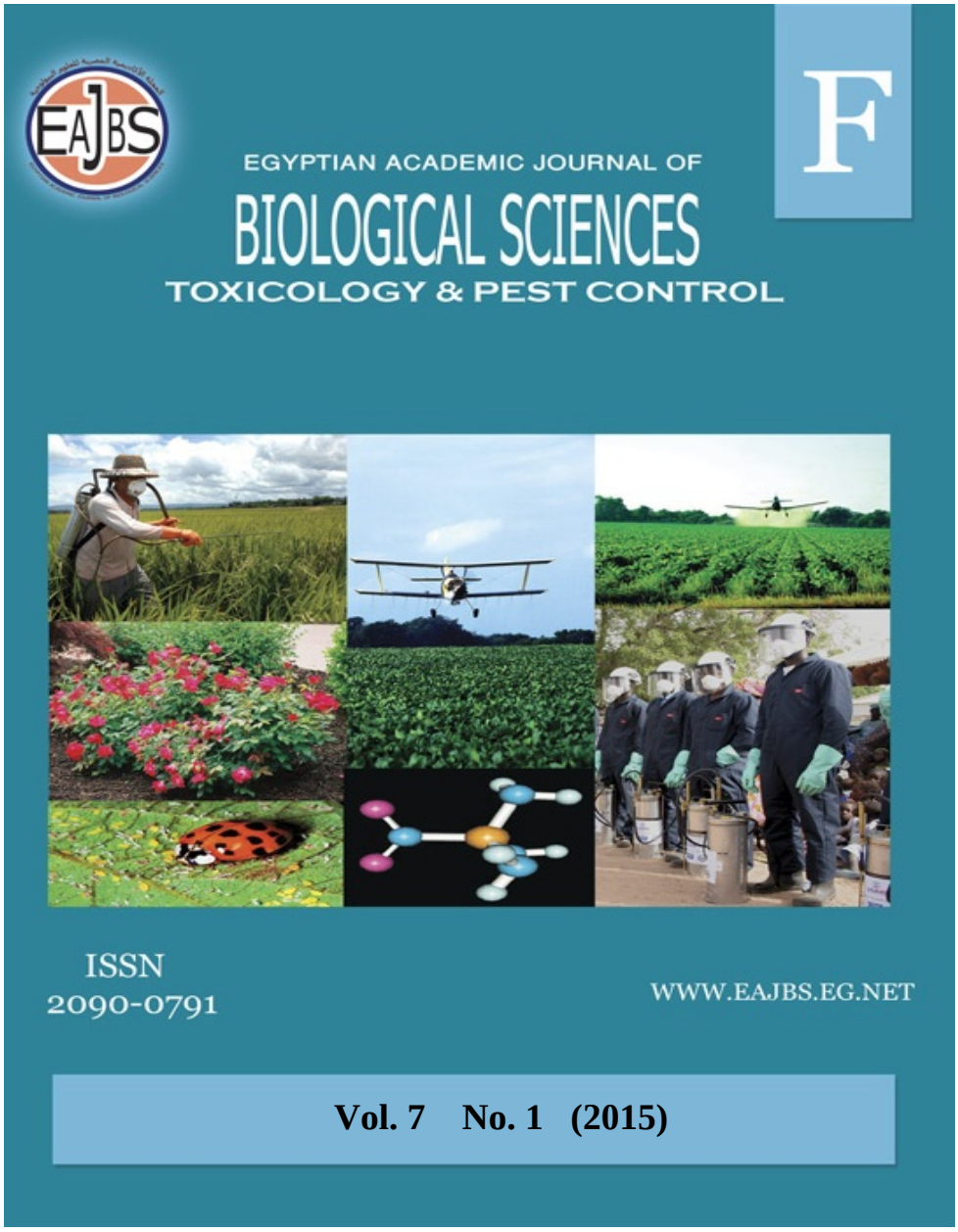

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Thermal Requirments And Life Tables Of *Dicrodiplosis manihoti* (Diptera, cecidomyiidae) As A predator Of *Phenacoccus parvus* (hemiptera, pseudococcidae)

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ABSTRACT

The effect of three degrees of temperature (20, 25 and 30^{o}C) and 55-60% RH, on biological aspects of *Dicrodiplosis manihoti* Harris as a predator of *Phenacoccus parvus* Morrison was studied. Temperature of 30^{o}C was the most suitable one for either development or reproduction.

Developmental times over tested temperatures revealed negative relation with temperature increase while developmental rates were positive. Female total developmental time was 43.3, 27.42 and 22.22 days at 20, 25 and 30^{o}C, respectively. Corresponding rates were 0.02, 0.04 and 0.05 per day at same temperatures. These rates were fitted to linear equation with R^2 = 0.98. Total thermal developmental requirement was 456.5 degree days over thermal threshold of 9.09^{o}C. Male developmental times, rates and thermal requirement for development were very similar. Adults longevity was relatively short (i.e. less than 5 days). Oviposition duration was two days regardless tested temperature. Total female life cycle was 47.90, 30.68 and 24.44 days for females at tested temperatures. Corresponding values for male were 48.44, 30.5 and 24.54 days, respectively. Fecundity per female was 32.10, 35.15 and 49.50 eggs/female over tested temperatures during its longevity of 4.80, 3.26 and 2.22 days, respectively.

Life table parameters showed highest values of net reproductive rate (R_o = 17.80), intrinsic rate of increase (r_m = 0.12), finite rate of increase (exp. r_m = 1.13) and the shortest mean generation time (23.92 days) at 30^{o}C.

INTRODUCTION

The lantana mealybug, *Phenacoccus parvus* (Hemiptera : Pseudococcidae) has a wide range of host plant. It was recorded on approximately 50 plant species, belonging to 26 families. These records include a number of agricultural crops (i.e. banana, guava, mango, potato, sweet pepper and tomato). It was collected in the Central Plain of Israel on *Wedalia triobata*, *Cestrum* and *Lantana camara* (Ben-Dove *et al.* 2005). In Queensland, observations suggested that, *P. parvus* has a very wide potential host range, which in the field included flannel weed (*Side cordifolia*), *Mallotus claoxyloides* trees and *Solanum stelligerum var. stelligerum*.

In greenhouse studies, mangoes, celery, cucumber and tomatoes were reported to be heavily infested (Swarbrick and Donaldson, 1991).

In Egypt, *P. parvus* was recorded recently infesting *Hibiscus* sp. (Abd-Rabou *et al*., 2010).

Dicrodiplosis manihoti Harris (Diptera: Cecidomyiidae) was recorded preying on cassava mealybug, *Phenacoccus manihoti* Matile-Ferrero infested cassava, *Manihot esculenta* Crantz (Harris, 1981). Also, it was reared on the long tailed mealybug, *Pseudococcus longispinus* (Targioni Tozzetti) that infest custard apple, citrus, copper leaf and Indian peach (Abbas, 1999). Moreover, *D. manihoti* was reared on the spherical mealybug, *Nipaecoccus vastator* (Maskell) (Al-Rubeae *et al*., 2011), the mexican mealybug, *Phenacoccus gossypii* Hall that infest *Hibiscus rosa- sinensis* L. (Rosaceae) (Skuhrava *et al*., 2014), the striped mealybug, *Ferrisia virgata* (Cockerell), and the citrus mealybug, *Planococcus citri* (Risso) (Gagne and Jaschhof, 2014). It was also reared on the cotton mealybug, *Phenacoccus solenopsis* (Attia and Ebrahim, 2015).

Geographical distribution of *D. manihoti* includes, Senegal, Democratic Republic of Congo (Harris, 1981), Oman (Abbas, 1999), Iraq (Al-Rubeae *et al*., 2011), Iran (Skuhrava *et al*., 2014a). In Egypt, *D. manihoti* was recorded for the first time in August 2013 at Alexandria, associated with the mealybug, *Phenacoccus gossypii* that infest *H. rosa-sinensis* (Skuhrava *et al*., 2014).

Bioloigical studies that previously conducted on *D. manihoti* on its prey *P. longispinus* in Oman Sultanate (Abbas, 1999) . This study was conducted at 27 ± 2^{o}C and 50 – 70 % RH. Results indicated incubating period as 2.8 days, larval stage lasted 11.4 days, pupal stage 10.1 days and the total number of eggs deposited/female as 36 during life span of 2.3 days. Another study was conducted in Egypt on, *P. solenopsis* (Attia and Ebrahim, 2015). This study was conducted under laboratory conditions of 32 and 25 ± 2^{o}C. Results indicated incubation period of 2.2, 3.3 days, larval duration of 8.8, 13.8 days, pupal duration of 7.3, 11.1 days at tested temperatures, respectively. Total number of eggs per female was 41.5, 40.2 during female longevity as 2.2 and 3.9 days, respectively.

The present study aimed at evaluating the effect of three tested temperatures on the biological aspects of *D. manihoti* as a predator of *P. parvus*.

MATERIALS AND METHODS

The used mealybug and its predator were collected from infested ornamental plant, *Lantana camara* at Giza region. The mealybug was identified at Scale Insect Department, Plant Protection Research Institute, Agric. Res. Center, Giza, Egypt as *P. parvus*. The associated predator was identified at Natural History Museum, London as *D. manihoti*.

The mealybug and its associated predator larvae were transferred to laboratory and cultured on sprouting potatoes tubers (in carton boxes) until predator adults' emergence. The mealybug was also mass reared on sprouting potato tubers in carton cages to be used as a prey.

Biological study of the predator was performed under three constant temperatures (i.e. 20, 25 and 30^{o}C) and 55 -60% RH. Newly hatched larvae of the predator were placed separately in plastic tubes (4 cm length – 4 cm diameter) with three gravid females of *P. parvus* and their crawlers. Fifty newly hatched larvae (as replicates) were used at each temperature and monitored three times per week until adult emergence. For estimating the average number of eggs deposited by each female, ten couples of newly emerged females and

males were kept in glass tubes (5 × 2 cm) covered with muslin in each constant temperature. Each couple was provided with three gravid females until death of adults. Observation was conducted daily. Statistical analysis was conducted using linear regression for the relation between temperature and developmental rates. Life table parameters were calculated according to Birch (1948) using Life 48 basic computer program (Abou–Setta *et al*. 1986).

RESULTS AND DISCUSSION

In this study, *P. parvus* and its associated predator, *D. manihoti* were recorded on the ornamental plant *L. camara* at Giza region, thermal requirement and life table of the predator on its prey *P. parvus* were studied.

Thermal effect and requirements for development:

Obtained results for developmental durations, rates and thermal requirements are presented in Tables (1 & 2) for female and male, respectively.

Developmental times over tested temperatures revealed negative relation with temperature increase while developmental rates were positive. Female total developmental time was 43.3, 27.42 and 22.22 days at 20, 25 and 30^{o}C, respectively for immature stages. Corresponding rates were 0.02, 0.04 and 0.05 per day. These rates were fitted to linear equation with R^2 of 0.98. Total developmental thermal requirement was 456.5 degree days over thermal threshold of 9.09^{o}C. Male developmental times, rates and thermal requirement for total development were very similar. Adults longevity was relatively short (i.e. less than 5 days). Total female life cycle was 47.9, 30.68 and 24.44 days for females at tested temperatures. Corresponding values for male were 48.44, 30.5 and 24.54 days, respectively.

Table 1:Thermal effect and requirements of *Dicrodiplosis manihoti* females as a predator of *Phenacoccus parvus* at different temperatures.

Variable	Temp. (^{o}C)	incubatn	Larva	Pupa	Total	Adult long.	Life cycle
Duration	20	3.9	24.3	15.1	43.3	4.6	47.9
	25	2.89	16.58	7.95	27.42	3.26	30.68
	30	2.28	13.22	6.72	22.22	2.22	24.44
Rate	20	0.26	0.04	0.07	0.02	0.22	0.02
	25	0.35	0.06	0.13	0.04	0.31	0.03
	30	0.44	0.08	0.15	0.05	0.45	0.04
Regression values	Intercept	-0.11	-0.03	-0.09	-0.02	-0.26	-0.02
	Slope	0.02	0.00	0.01	0.00	0.02	0.00
	t_0 (^{o}C)	6.00	7.88	11.24	9.09	11.04	9.30
	K (Degree days)	54.76	290.04	121.16	456.51	42.99	499.19
	R^2	1.00	1.00	0.94	0.98	0.98	0.99

Table 2: Thermal effect and requirements of *Dicrodiplosis manihoti* males as a predator of *Phenacoccus parvus* at different temperatures.

Variable	Temp. (^{o}C)	incubation	Larva	Pupa	Total	Adult long.	Life cycle
Duration	20	3.44	25.89	14.22	43.56	4.89	48.44
	25	2.88	16.25	8.00	27.13	3.38	30.50
	30	2.15	13.23	6.69	22.08	2.46	24.54
Rate	20	0.29	0.04	0.07	0.02	0.20	0.02
	25	0.35	0.06	0.13	0.04	0.30	0.03
	30	0.46	0.08	0.15	0.05	0.41	0.04
Regression values	Intercept	-0.07	-0.03	-0.08	-0.02	-0.20	-0.02
	Slope	0.02	0.00	0.01	0.00	0.02	0.00
	t_0 (^{o}C)	3.88	9.15	10.47	9.31	10.01	9.39
	K (Degree days)	57.48	270.60	126.40	447.69	49.58	497.26
	R^2	0.96	0.98	0.95	0.98	1.00	0.99

Incubation period of *D. manihoti* eggs in this study was 2.89, 2.28 days at 25 and 30°C, respectively. This period was reported as 2.8 days at 27°C and 50 - 70% RH. (Abbas, 1999). It was also reported as 3.3 and 2.2 days at 25 ± 2 and 32± 2°C, respectively (Attia and Ebrahim 2015).

Larval stage of this predator in this study lasted 16.6 and 13.2 days at 25 and 30°C, respectively when fed on *P. parvus*. This period was reported as 11.4 days at 27°C using *P. longispinus* as prey (Abbas, 1999) while it was reported as 13.8 and 8.8 days at 25 ± 2 and 30 ± 2°C, respectively when fed on *P. solenopsis* (Attia and Ebrahim, 2015).

Female pupal stage of *D. manihoti* in this study lasted 8.0 and 7.0 days at 25 and 30°C. This period was reported as 10.1 days at 27°C (Abbas, 1999) while it was reported as 11.1 and 7.3 days at 25 ± 2 and 30±2°C (Attia and Ebrahim, 2015).

Female total developmental period of *D. manihoti* in this study was averaged 27.4 and 22.2 days at 25 and 30°C, respectively. This period was reported as 28.2 and 18.2 days at 25 ± 2 and 30 ± 2°C on *P. solenopsis* (Attia and Ebrahim, 2015).

Data represented in Table 3 indicated that, mean number of eggs deposited per female was 32.1, 35.1 and 49.5 eggs during its longevity as, 4.8, 3.3 and 2.2 days over tested temperatures respectively. In this Concern, Attia and Ebrahim, 2015 mentioned that, total number of eggs per *D. manihoti* female when fed on *P. solenopsis* was 41.5, 40.2 during its longevity as 2.2 and 3.9 days, at 32 and 25 ± 2°C, respectively. Fecundity of *D. manihoti* female when fed on *P. longispinus* was also reported as 36 eggs / female during its life span of 2.3 days at 27°C (Abbas, 1999).

Table 3. Fecundity and adult female longevity of *D. manihoti* on three tested temperatures

Parameter	20 °C	25°C	30°C
Mean number of eggs / female ± SE	32.10 ± 1.59	35.15 ± 1.23	49.5 ± 0.96
Longevity of adult female (day) ± SE	4.80 ± 0.13	3.26 ± 0.10	2.22 ± 0.10

Effect of temperature on life table parameters:

Obtained results for life table parameters are presented in Table (4). Tested temperatures affected survival rates of immature stages to adult stage. Least survival rate as 0.38 was obtained at 20°C while 0.54 and 0.62 were obtained at 25 and 30°C respectively.

Table 4. Life table parameters of *Dicrodiplosis manihoti* at different temperatures.

Parameter	20 °C	25 °C	30 °C
Survival to maturity	0.38	0.54	0.62
Sex ratio (females/total)	0.53	0.70	0.58
The net reproductive rate (R_o)	6.416	13.489	17.800
Mean generation time (T)	47.604	26.668	23.916
The intrinsic rate of increase (r_m)	0.039	0.100	0.120
The finite rate of increase (exp. r_m)	1.039	1.102	1.128
Time of population doubling ((In2 / r_m))	17.773	6.931	5.776

Sex ratio was also affected by tested temperature. Maximum sex ratio (female / total) as 0.70 was obtained at 25°C while values of 0.53 and 0.58 were obtained at 20 and 30°C, respectively. The net reproductive rate (R_o) varied according to the used temperature. Respective records of 6.42, 13.49, 17.8 females/female were recorded at 20, 25 and 30°C. Accordingly, it seems that 30°C is the most favorable temperature

for reproduction; showing the highest value of net reproductive rate.

From the mean generation time (T), evident differences were observed between the three temperatures. This period decreased with the increase of temperature. Respective average values of 47.60, 26.67 and 23.92 days were reported at 20, 25 and 30^{o}C.

Associating with the three tested temperatures, the intrinsic rate of increase (^{r}m) were in respective 0.039, 0.100 and 0.120. when these were converted into finite rates of increase (exp. r_m), the population of *D. manihoti* had the capacity to increase by the respective values 1.039, 1.102 and 1.128 times/female/day when reared at 20, 25 and 30^{o}C; showing the highest capacity to increase at 30^{o}C. Population doubling time (In (2) / r_m) was estimated to be 17.77, 6.93 and 5.78 days at tested temperatures (Table 4).

Obtained results indicated that this dipteran predator is a potential natural enemy of *P. parvus*. It is expected to be more efficient at worm temperatures (i.e. over 25^{o}C).

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