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THERMAL REQUIRMENTS, BIOLOGICAL AND LIFE TABLE PARAMETERS OF *Exochomus nigromaculatus* (GOEZE) (Coleoptera: Coccinellidae) REARED ON THREE APHID SPECIES.

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ABSTRACT

Developmental time and rate of immature stages, growth index, survival percentage, longevity, fecundity, and life table parameters of *Exochomus nigromaculatus* (Goeze) when reared on *Aphis gossypii, Aphis craccivora,* and *Myzus persicae* were studied at three constant temperatures (20, 24, and 28ºC). The relationship between developmental rate of each stage and tested temperatures was also regressed.

There were significant variations in total developmental time of immature stages of the predator (male and female) among the three tested temperatures when the predators reared on the three studied preys. Meanwhile, there were no significant variations among the three aphid species at the same temperature. Growth index and developmental rate of *E. nigromaculatus* male were higher at 28ºC than 20 and 24ºC when reared on the tested aphid species. Survival percentage of immature stages when reared at 24 and 28ºC was higher (100%) on *M. persicae* than on *A. gossypii* and *A. crccivora* (90%). *Exochomus nigromaculatus* male and female required 263.16 DD to complete their development from egg to adult male when reared on when it was reared on *A. gossypii, A. craccivora*, and *M. persicae*. There were no significant differences in pre-ovipositional period among the three tested temperatures. In addition, there were significant variations between inter-oviposition, oviposition, and total longevity when the predator was reared at the three tested temperatures. Male longevity was significantly shorter at 28ºC than at 20ºC and 24ºC which fed on the same prey. Fecundity rate was significantly higher at 28ºC than at 20ºC and 24ºC, when fed on the same prey. The mean generation time (T) and doubling time (DT) were shorter at 28ºC than at 20ºC and 24ºC when fed on the same prey at 28ºC. Generally, the value of gross reproductive rate (GRR), the net reproduction rate (R_o), the intrinsic rate of increase (r_m), the finite rate of increase (λ) were higher at 28ºC than at 20ºC and 24ºC.

Keywords: *Exochomus nigromaculatus*, thermal requirements, biological characteristic, life table, *Aphis gossypii, Aphis craccivora, Myzus persicae*.

INTRODUCTION

Family Coccinellidae is potentially an important predatory insect group found throughout the world on many economic crops. Some species may have a significant role in biological control of aphid species, whiteflies, and other soft-bodied insects. *Exochomus nigromaculatus* (Goeze) is considered an useful biological control candidate for limiting the abundance of aphids, insect eggs, coccids, and other soft bodied insects in cultivated crops in Egyptian agroecosystem (El-Serafi, 2006 and Mohamed *et al.,* 2008). Several studies drew attention to the importance of this coccinellid species as a predator. This coccinellid predator could make a good candidate for mass rearing and release in pest hot spot infestations in open fields and greenhouses, because it has a good search activity and a high consumption rate (Atlihan and Kaydan, 2002; Atlihan and Özgökçe, 2002; El-Serafi, 2006 and Mohamed *et al.,* 2008). In order to use this predator in biological control programs, it is necessary to understand biological and life table attributes for it prior to mass production and release. Knowledge of biological parameters is essential for assessing the potential rate of increase for a population.

Life table parameters are essential to know the general biology of an insect and provide a valuable picture for the fecundity and growth potential of *E. nigromaculatus* under prevailing environmental conditions. Population growth rate is a basic ecological characteristic. It is usually expressed as the intrinsic rate of natural increase (r_m) which is regarded as the best available single description of the population growth of a species under given conditions (Southwood and Henderson, 2000). The intrinsic rate of natural increase (r_m) can be used for predator's selection. Morever, r_m is a suitable for evaluation of the mass rearing quality of biological control agents. It can be determined by its developmental time and reproduction rate. It has been used to compare a species under different environmental conditions and as an index of population rate response to selected preys (Birch, 1948; Hulting *et al.*, 1990.; Roy *et al.*, 2003 and Lanzoni *et al.,* 2004)

However, scanty attention has been paid to the developmental time and rate, growth index, longevity, fecundity and life table parameters of this predator to measure these parameters for mass rearing and release. Therefore, the present study was designed to study certain themal requirements, biological characters and life table parameters of *E. nigromaculatus* at three constant temperatures on three preys.

MATERIALS AND METHODS

I. Rearing of immature stages:

Adults of *E. nigromaculatus* were collected from the fields at the Experimental Research Station, Faculty of Agriculture, Mansoura University and reared on *Aphis gossypii* Glover. The eggs laid by females were collected daily, and monitored until hatching. To avoid cannibalism, hatched larvae were reared individually in petri dishes (9 cm in diameter) in the incubators at 20±0.5, 24±0.5 and 28±0.5ºC. The relative humidity was 60.0±5.0% and the photoperiod was 14:10 (L: D) with each temperature. A piece of filter paper was placed on the bottom of each dish to provide a walking surface for the larvae. Twenty larvae from the predator were reared on three aphid species namely, *A. gossypii, Aphis craccivora* Koch., and *Myzus persicae* (Sulzer). Each reared larva was considered a replicate. The developmental time and rate (1/developmental time) (Omakar and James, 2004) of immature stages, survival from eggs to adult eclosion, and sex ratio were recorded. The ability of the larvae to moult and metamorphose on the tested preys was determined as (a) percentage of individuals transforming into adults, and (b) average period required. The ratio of (a) to (b) then represented the insect's "growth index" (Saxena, 1969).

Developmental times for eggs, larval instars, total larval stage, pupal stage as well as total immature stages were used to calculate development rates, which were regressed against temperature. The regression parameters and slopes were used to estimate the lower temperature threshold for developmental (to) and the thermal constant K, as described by Campbell *et al.* (1974).

II. Rearing of adult stage:

After eclosion, 10 males and 10 females from this predator were also fed on the three tested aphid species until development was completed. The longevity of females was divided to three periods according to Phoofolo and Obrycki (1995) and Lanzoni *et al.* (2004). The pre-oviposition period was measured as the number of days between female eclosion and initiation of egg laying, while inter-oviposition one as the number of days between two successive ovipositions, and finally the oviposition period was the number of days during which oviposition occurred. The fecundity of female, fecundity rate (number of progeny produced per female per day) and the longevity of males were recorded.

Life table parameters were calculated using a BASIC computer program (Abou-Setta *et al.* 1986) for females reared on the three tested aphid species. This computer program is based on Birch's method (1948) for the calculation of an animal's life table. Constructing a life table, using rates of age-specific (Lx), and fecundity (Mx) for each age interval (x) was assessed. The following population growth parameters were determined: the mean generation time (*T*), gross reproductive rate (GRR) (=ΣMx), the net reproductive increase (R_o), the intrinsic rate of increase (r_m), and the finite rate of increase (λ). The doubling time (*DT*) was calculated according to Mackauer's method (Mackauer, 1983). The life tables were prepared from data recorded daily on developmental time (egg to first egg laid), sex ratio, the number of deposited eggs, the fraction of eggs reaching maturity, and the survival of females. Interval of one day was chosen as the age classes for constructing the life table.

III. Data analysis:

Data of developmental times of immature stages, consumption of larvae and adults, pre-oviposition, inter-oviposition, and oviposition periods, total longevity of females, fecundity, fecundity rate, and the males longevity of *E. nigromaculatus* reared on *A. gossypii, A. craccivora*, and *M. persicae* at three tested temperatures were subjected for one way analysis of variance (ANOVA), and the means were separated using Duncan's Multiple Range Test (CoHort Software, 2004).

RESULTS

1- Developmental times of immature stages

A. Male

Analysis of variance (ANOVA) indicated that there was significant variations in the incubation periods for male among the three tested temperatures (20, 24, and 28^{o}C), when the predators reared on the three tested preys (*A. gossypii, A. craccivora*, and *M. persicae*) (Table 1). Meanwhile, there were no significant variations among the three aphid species at the same temperature.

Data in Table (1) showed that developmental time of the four larval instars was 4.2, 4.1, 4.2, and 6.4 days, respectively at 20ºC, 3.4, 3.1, 3.2, and 4.3 days at 24ºC, and 2.2, 2.2, 2.2, and 3.1 days in succession at 28ºC, with no significant difference in 1st, 2nd, and 3rd instar larvae when reared the predator on *A. gossypii* as a prey. While in the 4th instar, there was a significant variation among the three tested temperatures. The developmental time of larval stage was 18.9, 14.0, and 9.5 days, with a significant differences among the three tested temperatures. The pupal stage averaged 15.6, 10.2, and 4.7 days at 20, 24, and 28ºC, with a significant difference. The total developmental time of immature stages was 45.8, 33.6, and 20.5 days at 20, 24, and 28ºC with a significant difference.

Table (1) showed that developmental times of the four larval instars, when reared *E. nigromaculatus* on *A. craccivora* were 4.1, 4.2, 4.2, and 6.3 days, respectively at 20ºC, 3.3, 3.2, 3.2, and 4.3 days at 24ºC, and 2.1, 2.2, 2.2, and 3.4 days in succession at 28ºC with no significant differences in 1st, 2nd, and 3rd instar larvae. While in the 4th instar, there was a significant variation between the three tested temperatures. The developmental time of larval stage was 18.8, 14.0, and 9.9 days, with a significant difference between the three tested temperatures. The pupal stage averaged 15.7, 10.4, and 4.7 days at 20, 24, and 28ºC, with a significant difference. The total developmental time of immature stages was 45.8, 33.8, and 20.9 days at 20, 24, and 28ºC, with a significant difference.

On *M. persicae* as a prey, data in Table (1) showed that developmental times of the four larval instars were 4.3, 4.3, 4.3, and 6.4 days, respectively at 20ºC, 3.2, 3.3, 3.3, and 4.3 days at 24ºC, and 2.2, 2.3, 2.3, and 3.3 days in succession at 28ºC, with no significant differences in 1st, 2nd, and 3rd instar larvae. While in the 4th instar, there was a significant variation among the three tested temperatures. The developmental time of larval stage was 19.3, 14.1, and 10.1 days with a significant difference among the three tested temperatures. The pupal stage averaged 15.8, 10.3, and 4.7 days at 20, 24, and 28ºC with a significant difference. The total developmental times of immature stages were 46.4, 33.8, and 21.1 days at 20, 24, and 28ºC, with a significant difference.

B. Female

Based on the statistical analysis, there were significant variations in the incubation period for females among the three tested temperatures (20, 24, and 28ºC), when the female predators reared on the three tested preys (*A. gossypii, A. craccivora*, and *M. persicae*) (Table 2).

Table (1). Developmental times (mean±SE) in days of immature stages of *E. nigromaculatus* male when reared on three prey species at three constant temperatures.

Prey species	Temp. (ºC)	Egg	Larval instars 1st	2nd	3rd	4th	Total	Pupal stage	Total
A. gossypii	20	11.3± 0.78 a^{A}	4.2± 0.75 a^{A}	4.1± 0.68 a^{A}	4.2± 0.75 a^{A}	6.4± 0.79 a^{A}	18.7± 0.93 a^{A}	15.6± 0.88 a^{A}	45.4± 1.14 a^{A}
	24	9.4± 0.80 ab^{A}	3.4± 0.80 a^{A}	3.1± 0.68 a^{A}	3.2± 0.75 a^{A}	4.3± 0.78 b^{A}	13.9± 1.01 b^{A}	10.2± 0.75 b^{A}	33.4± 0.88 b^{A}
	28	6.3± 0.78 b^{A}	2.2± 0.75 a^{A}	2.1± 0.68 a^{A}	2.1± 0.68 a^{A}	3.1± 0.68 b^{A}	9.6± 0.88 c^{A}	4.7± 0.78 c^{A}	20.4± 0.94 c^{A}
A. craccivorae	20	11.3± 0.78 a^{A}	4.1± 0.68 a^{A}	4.2± 0.75 a^{A}	4.2± 0.75 a^{A}	6.3± 0.78 a^{A}	19.1± 0.90 a^{A}	15.7± 0.78 a^{A}	46.0± 1.05 a^{A}
	24	9.4± 0.80 ab^{A}	3.3± 0.78 a^{A}	3.2± 0.75 a^{A}	3.2± 0.75 a^{A}	4.3± 0.78 b^{A}	14.0± 1.03 b^{A}	10.4± 0.79 b^{A}	33.6± 0.94 b^{A}
	28	6.3± 0.78 b^{A}	2.1± 0.68 a^{A}	2.2± 0.75 a^{A}	2.2± 0.75 a^{A}	3.4± 0.80 b^{A}	9.8± 1.02 c^{A}	4.7± 0.78 c^{A}	20.4± 0.94 c^{A}
M. persicae	20	11.3± 0.78 a^{A}	4.3± 0.78 a^{A}	4.3± 0.78 a^{A}	4.3± 0.78 a^{A}	6.4± 0.80 a^{A}	19.3± 1.00 a^{A}	15.8± 0.86 a^{A}	46.2± 0.75 a^{A}
	24	9.4± 0.80 ab^{A}	3.2± 0.75 a^{A}	3.3± 0.78 a^{A}	3.3± 0.78 a^{A}	4.3± 0.78 b^{A}	14.1± 0.98 b^{A}	10.3± 0.78 b^{A}	34.0± 0.87 b^{A}
	28	6.3± 0.78 b^{A}	2.2± 0.75 a^{A}	2.3± 0.78 a^{A}	2.3± 0.78 a^{A}	3.3± 0.78 b^{A}	10.1± 0.89 c^{A}	4.7± 0.78 c^{A}	21.1± 0.82 c^{A}

[a]Means followed by the same small letter in a column among the three temperatures on each prey species or same capital letter in a column among the three prey species at the same temperature are not significantly different at the 1% level of probability (Duncan's MultipleRangeTest).

Table (2). Developmental times (mean±SE) in days of immature stages of *E. nigromaculatus* female when reared on three prey species at three temperatures.

Prey species	Temp. (ºC)	Egg	Larval instar 1st	2nd	3rd	4th	Total	Pupa	Total
A. gossypii	20	11.3± 0.78 a^{A}	4.3± 0.78 a^{A}	4.2± 0.75 a^{A}	4.3± 0.78 a^{A}	6.4± 0.80 a^{A}	19.2± 0.96 a^{A}	15.4± 0.79 a^{A}	45.8± 1.01 a^{A}
	24	9.4± 0.80 ab^{A}	3.4± 0.80 a^{A}	3.4± 0.80 a^{A}	3.4± 0.80 a^{A}	4.3± 0.78 b^{A}	14.2± 0.97 b^{A}	10.2± 0.75 b^{A}	33.8± 0.92 b^{A}
	28	6.3± 0.78 b^{A}	2.1± 0.68 a^{A}	2.2± 0.75 a^{A}	2.2± 0.75 a^{A}	3.1± 0.68 b^{A}	9.6± 1.06 c^{A}	4.7± 0.78 c^{A}	20.2± 0.86 c^{A}
A. craccivorae	20	11.3± 0.78 a^{A}	4.3± 0.78 a^{A}	4.2± 0.75 a^{A}	4.3± 0.78 a^{A}	6.4± 0.80 a^{A}	19.0± 0.98 a^{A}	15.7± 0.78 a^{A}	46.0± 0.98 a^{A}
	24	9.4± 0.80 ab^{A}	3.4± 0.80 a^{A}	3.4± 0.80 a^{A}	3.4± 0.80 a^{A}	4.3± 0.78 b^{A}	14.3± 0.96 b^{A}	10.3± 0.78 b^{A}	33.9± 1.03 b^{A}
	28	6.3± 0.78 b^{A}	2.1± 0.68 a^{A}	2.2± 0.75 a^{A}	2.2± 0.75 a^{A}	3.3± 0.78 b^{A}	9.9± 1.04 c^{A}	4.7± 0.78 c^{A}	20.4± 0.96 c^{A}
M. persicae	20	11.3± 0.78 a^{A}	4.4± 0.80 a^{A}	4.3± 0.78 a^{A}	4.4± 0.80 a^{A}	6.4± 0.80 a^{A}	19.5± 1.01 a^{A}	15.7± 0.78 a^{A}	46.3± 1.02 a^{A}
	24	9.3± 0.78 ab^{A}	3.3± 0.78 a^{A}	3.3± 0.78 a^{A}	3.3± 0.78 a^{A}	4.4± 0.80 b^{A}	14.3± 1.06 b^{A}	10.3± 0.78 b^{A}	34.0± 0.92 b^{A}
	28	6.3± 0.78 b^{A}	2.2± 0.75 a^{A}	2.2± 0.75 a^{A}	2.3± 0.78 a^{A}	3.3± 0.78 b^{A}	10.0± 0.78 c^{A}	4.6± 0.80 c^{A}	21.0± 0.78 c^{A}

[a]Means followed by the same small letter in a column among the three temperatures on each prey species or same capital letter in a column among the three prey species at the same temperature are not significantly different at the 1% level of probability (Duncan's Multiple Range test)

Meanwhile, there were no significant variations among the three aphid species at the same temperature (Table 2).

Data in Table (2) showed that developmental times of the four larval instars were 4.3, 4.2, 4.3, and 6.4 days, respectively at 20ºC, 3.4, 3.4, 3.4, and 4.3 days at 24ºC, and 2.1, 2.2, 2.2, and 3.1 days in succession at 28ºC, with no significant differences in 1st, 2nd, and 3rd instar larvae when reared the predator on *A. gossypii* as a prey. While in the 4th instar, there was a significant variation among the three tested temperatures. The developmental time of larval stage was 19.2, 14.5, and 9.6 days with a significant difference among the three tested temperatures. The pupal stage averaged 15.4, 10.2, and 4.7 days at 20, 24, and 28ºC, with a significant difference. The total developmental time of immature stages was 45.9, 34.1, and 20.6 days at 20, 24, and 28ºC, with a significant difference.

Table (2) showed that developmental times of the four larval instars when reared *E. nigromaculatus* on *A. craccivora* were 4.3, 4.2, 4.3, and 6.4 days, respectively at 20ºC, 3.4, 3.4, 3.4, and 4.3 days at 24ºC, and 2.1, 2.2, 2.2, and 3.3 days in succession at 28ºC, with no significant difference in 1st, 2nd, and 3rd instar larvae. While in the 4th instar, there was a significant variation among the three tested temperatures. The developmental times of larval stage were 19.2, 14.5, and 9.8 days, with a significant difference among the three tested temperatures. The pupal stage averaged 15.7, 10.3, and 4.7 days at 20, 24, and 28ºC, with a significant difference. The total developmental time of immature stages was 46.0, 34.2, and 20.8 days at 20, 24, and 28ºC, with a significant difference.

On *M. persicae* as a prey, data in Table (2) showed that developmental times of the four larval instars were 4.4, 4.3, 4.4, and 6.4 days, respectively at 20ºC, 3.3, 3.3, 3.3, and 4.4 days at 24ºC, and 2.2, 2.2, 2.3, and 3.3 days in succession at 28ºC, with no significant difference in 1st, 2nd, and 3rd instar larvae. While in the 4th instar, there was a significant variation among the three tested temperatures. The developmental time of larval stage was 19.5, 14.3, and 10.0 days, with a significant difference among the three tested temperatures. The pupal stage averaged 15.7, 10.3, and 4.6 days at 20, 24, and 28ºC, with a significant difference. The total developmental time of immature stages was 46.5, 33.9, and 20.9 days at 20, 24, and 28ºC, with a significant difference.

2. Growth index (GI) and developmental rate (DR)

Growth index of *E. nigromaculatus* male was 1.97, 2.68, and 4.39 at the three tested temperatures (20, 24, and 28ºC, respectively) when reared on *A. gossypii* (Table 3). Meanwhile for female, they were 1.96, 2.64, and 4.37 at the three tested temperatures. GI of *E. nigromaculatus* male was 1.97, 2.66, and 4.31 at the three tested temperatures (20, 24, and 28ºC, respectively), when reared on *A. craccivora* (Table 3). Meanwhile for female, they were 1.96, 2.63, 4.33 at the three tested temperatures. GI of *E.*

nigromaculatus male was 1.94, 2.96, and 4.74 at the three tested temperatures (20, 24, and 28ºC, respectively) when reared on *M. persicae* (Table 3). Meanwhile for female, they were 1.94, 2.95, and 4.78 at the three tested temperatures.

Developmental rates of *E. nigromaculatus* male and female were 0.02, 0.03, and 0.05 at the three tested temperatures (20, 24, and 28ºC, respectively), when reared on *A. gossypii* (Table 3). DR of *E. nigromaculatus* male and female was 0.02, 0.03, and 0.05 at the three tested temperatures respectively, when reared on *A. craccivora* (Table 3). DR of *E. nigromaculatus* male and female was 0.02, 0.03, and 0.05 at the three tested temperatures, respectively when reared on *M. persicae* (Table 3).

In general, GI and DR were better for *E. nigromaculatus* adults (male and female) when reared on the three tested preys (*A. gossypii, A. craccivora*, and *M. persicae*) at 28ºC than at 20 and 24ºC.

Table (3). Growth index and developmental rate of male and female of *E. nigromaculatus* reared on different aphid species at different temperatures.

Prey species	Sex	Temp. (ºC)	Growth index	Developmental rate
A .gossypii	♂	20	1.97	0.02
		24	2.68	0.03
		28	4.39	0.05
	♀	20	1.96	0.02
		24	2.64	0.03
		28	4.37	0.05
A. craccivora	♂	20	1.97	0.02
		24	2.66	0.03
		28	4.31	0.05
	♀	20	1.96	0.02
		24	2.63	0.03
		28	4.33	0.05
M. persicae	♂	20	1.94	0.02
		24	2.96	0.03
		28	4.74	0.05
	♀	20	1.94	0.02
		24	2.95	0.03
		28	4.78	0.05

3. Survival percentage:

Survival percentages of larval instars, pupal stage, and total immature stages of *E. nigromaculatus* male were 100, 100, 100, 90, 100, and 90% at 20ºC, 90, 100, 100, 100, 100, and 90% at 24ºC, and 100, 100, 90, 100, 100, and 90% at 28ºC when reared on *A. gossyppii* (Table 4). Meanwhile for female, they was 90, 100, 100, 100, 100, and 90% at 20ºC, 100, 100, 100, 90, 100, and 90% at 24ºC, and 90, 100, 100, 100, 100, and 90% at 28ºC.

Survival percentages of larval instars, pupal stage, and total immature stages of *E. nigromaculatus* male were 90, 100, 100, 100, 100, and 90% at 20ºC, 100, 100, 100, 100, 90, and 90% at 24ºC, and 100, 100, 100, 90, 100, and 90% at 28ºC when reared on *A. craccivora* (Table 4). Meanwhile for female, they was 100, 100, 90, 100, 100, and 90% at 20ºC, 100, 100, 100, 100, 90, and 90% at 24 and 28ºC.

Survival percentages of larval instars, pupal stage, and total immature stages of *E. nigromaculatus* male were 100, 90, 100, 100, 100, and 90% at 20ºC, 100, 100, 100, 100, 100, and 100% at 24 and 28ºC, when reared on *M. persicae* (Table 4). The same trend was recorded with female.

Generally, data in Table (4) indicated that the survival percentages of immature stages when reared at 24 and 28ºC were higher (100%) on *M. persicae* than on *A. gossypii* and *A. crccivora* (90%).

Table (4). Survival percentages of immature stages of of male and female of *E. nigromaculatus* reared on different aphid species at different temperatures.

Prey species	Sex	Temp. (ºC)	Larval instars				Pupa	Total
			1st	2nd	3rd	4th		
A .gossypii	♂	20	100.0	100.0	100.0	90.0	100.0	90.0
		24	90.0	100.0	100.0	100.0	100.0	90.0
		28	100.0	100.0	90.0	100.0	100.0	90.0
	♀	20	90.0	100.0	100.0	100.0	100.0	90.0
		24	100.0	100.0	100.0	90.0	100.0	90.0
		28	90.0	100.0	100.0	100.0	100.0	90.0
A. craccivora	♂	20	90.0	100.0	100.0	100.0	100.0	90.0
		24	100.0	100.0	100.0	100.0	90.0	90.0
		28	100.0	100.0	100.0	90.0	100.0	90.0
	♀	20	100.0	100.0	90.0	100.0	100.0	90.0
		24	100.0	100.0	100.0	100.0	90.0	90.0
		28	100.0	100.0	100.0	100.0	90.0	90.0
M. persicae	♂	20	100.0	90.0	100.0	100.0	100.0	90.0
		24	100.0	100.0	100.0	100.0	100.0	100.0
		28	100.0	100.0	100.0	100.0	100.0	100.0
	♀	20	100.0	100.0	100.0	100.0	90.0	90.0
		24	100.0	100.0	100.0	100.0	100.0	100.0
		28	100.0	100.0	100.0	100.0	100.0	100.0

4. Degree-Day Requirements:

Minimum developmental thresholds (T_o) of egg stage, four larval instars, larval stage, pupal stage, and total immature stages of *E. nigromaculatus* male were 10.23, 12.27, 10.40, 12.56, 12.00, 8.66, 17.02, and 14.92⁰C, respectively, when reared on *A. gossypii* (Table 5). Concerning the female, correspondent values were 10.23, 12.56, 12.20, 12.27, 12.17, 13.77, 17.02, and 14.92⁰C, respectively, when reared on *A. gossypii* (Table 6).

Minimum developmental thresholds of egg stage, larval instars, larval stage, pupal stage, and total immature stages of *E. nigromaculatus* male were 10.23, 12.67, 12.20, 12.78, 10.67, 12.18, 17.67, and 14.92⁰C, respectively, when reared on *A. craccivora* (Table 5). Regarding the females, correspondent values were 10.23, 12.67, 12.20, 12.78, 11.67, 12.18, 17.67 and 14.92⁰C, respectively (Table 6).

Minimum developmental thresholds of egg stage, larval instars, larval stage, pupal stage, total immature stages of *E. nigromaculatus* male were 10.23, 12.43, 11.32, 11.32, 11.35, 12.18, 17.67, and 14.92^{0}C, respectively when reared on *M. persicae* (Table 5). For female, correspondent values were 10.23, 12.78, 12.20, 12.00, 11.53, 12.18, 17.67 and 14.92^{0}C, respectively (Table 6).

Exochomus nigromaculatus male and female required 263.16 DD to complete their development from egg stage to adult male, when reared on when reared on *A. gossypii, A. craccivora*, and *M. persicae* (Tables 5 and 6).

Table (5). Linear regression analysis of temperatures versus developmental rates, degree-days requirements, and minimum developmental thresholds of *E. nigromaculatus* male when reared on *A. gossypii, A. craccivora*, and *M. persicae*.

Predator stage or instar	Regression equation	R^2	DD's	T_0
A. gossypii				
Egg stage	Y = - 0.09+0.0088x	0.9423	113.64	10.23
1st L	Y = - 0.3533+0.0288x	0.9292	34.72	12.27
2nd L	Y =- 0.26 +0.025x	0.9709	40.00	10.40
3rd L	Y = - 0.3767+0.03x	0.9453	33.33	12.56
4th L	Y = - 0.24+0.02x	1	50.00	12.00
Larval stage	Y = - 0.0433+0.005x	0.9231	200.00	8.66
Pupal stage	Y = - 0.32+0.0188x	0.8929	53.19	17.02
Total	Y = - 0.0567+0.0038x	0.9643	263.16	14.92
A. craccivora				
Egg stage	Y = - 0.09+0.0088x	0.9423	113.64	10.23
1st L	Y = - 0.38+0.03x	0.9231	33.33	12.67
2nd L	Y = - 0.35+0.0287x	0.9514	34.84	12.205
3rd L	Y = - 0.3833+0.03x	0.9643	33.33	12.78
4th L	Y = - 0.1867+0.0175x	0.9932	57.14	10.67
Larval stage	Y = - 0.0767+0.0063x	0.9868	158.73	12.18
Pupal stage	Y = - 0.3533+0.02x	0.9231	50.00	17.67
Total	Y = - 0.0567+0.0038x	0.9643	263.16	14.92
M. persicae				
Egg stage	Y = - 0.09+0.0088x	0.9423	113.64	10.23
1st L	Y = - 0.3567+0.0287x	0.9038	34.84	12.43
2nd L	Y = - 0.2967+0.0262x	0.9643	38.17	11.32
3rd L	Y = - 0.2967+0.0262x	0.9643	38.17	11.32
4th L	Y = - 0.2133+0.0188x	0.9985	53.19	11.35
Larval stage	Y = - 0.0767+0.0063x	0.9868	158.73	12.18
Pupal stage	Y = - 0.3533+0.02x	0.9231	50.00	17.67
Total	Y = 0.0567+0.0038x	0.9643	263.16	14.92

Table (6). Linear regression analysis of temperatures versus developmental rates, degree-days requirements, and minimum developmental thresholds of *E. nigromaculatus* female when reared on *A. gossypii, A. craccivora*, and *M. persicae*.

Predator stage or instar	Regression equation	R^2	DD's	T_0
A. gossypii				
Egg stage	Y = - 0.09+0.0088x	0.9423	113.64	10.23
1st L	Y = - 0.3767+0.03x	0.9453	33.33	12.56
2nd L	Y = - 0.35+0.0287x	0.9514	34.84	12.20
3rd L	Y = - 0.3533+0.0288x	0.9292	34.72	12.27
4th L	Y = - 0.2433+0.02x	0.9948	50.00	12.17
Larval stage	Y = - 0.1033 +0.0075x	0.9643	133.33	13.77
Pupal stage	Y = - 0.32+0.0188x	0.8929	53.19	17.02
Total	Y =- 0.0567 +0.0038x	0.9643	263.16	14.92
A. craccivora				
Egg stage	Y = - 0.09+0.0088x	0.9423	113.64	10.23
1st L	Y = - 0.38+0.03x	0.9231	33.33	12.67
2nd L	Y = - 0.35+0.0287x	0.9514	34.84	12.20
3rd L	Y = - 0.3833+0.03x	0.9643	33.33	12.78
4th L	Y = - 0.1867+0.0175x	0.9932	57.14	10.67
Larval stage	Y = - 0.0767+0.0063x	0.9868	158.73	12.18
Pupal stage	Y = - 0.3533+0.02x	0.9231	50.00	17.67
Total	Y= - 0.0567+0.0038x	0.9643	263.16	14.92
M. persicae				
Egg stage	Y =- 0.09+0.0088x	0.9423	113.64	10.23
1st L	Y = - 0.3833+0.03x	0.9643	33.33	12.78
2nd L	Y =- 0.35 +0.0287x	0.9514	34.84	12.20
3rd L	Y = - 0.33+0.0275x	0.9758	36.36	12.00
4th L	Y = - 0.2167+0.0188x	0.9985	53.19	11.53
Larval stage	Y= - 0.0767+0.0063x	0.9868	158.73	12.18
Pupal stage	Y = - 0.3533+0.02x	0.9231	50.00	17.67
Total	Y = - 0.0567+0.0038x	0.9643	263.16	14.92

5. Longevity and fecundity of adult stage:

Longevity and fecundity of *E. nigromaculatus* when reared on *A. gossypii, A. craccivora*, and *M. persicae* at the three tested temperatures (20, 24, and 28ºC) are given in Table (7).

On *A. gossypii* as a prey, pre-ovipositional, inter-oviposition, ovipositional, and total longevity periods lasted 11.2, 36.8, 57.2, and 104.2 days, respectively at 20ºC, while these periods lasted 10.1, 23.3, 37.9, and 71.3 days at 24ºC, and 9.7, 24.6, 30.1, and 64.4 days at 28ºC. There were no significant differences in pre-ovipositional period among the three tested temperatures. In addition, there were significant variations between inter-oviposition, oviposition, and total longevity when the predator was reared at the three tested temperatures (Table 7). Male longevity was significantly shorter (55.5 days) at 28ºC than at 20ºC and 24ºC (95.5 and 62.5 days) which fed on the same prey. Concerning the fecundity of females, the average number of eggs per female was 489.3, 516.3, and 549.8, with significant differences among the three tested temperatures (Table 7). In addition, results in Table (7) showed that fecundity rate was significantly higher (18.3) at 28ºC than at 20ºC and 24ºC (8.5 and 13.6) when fed on the same prey.

Table (7) Longevity (mean±SE) in days of *E. nigromaculatus* when reared on certain aphid species at different temperatures.

Aphis species	Temp. (ºC)	Sex	Longevity				Mean total fecundity	Fecundity rate (No. eggs/Female / day)
			Pre-oviposition	Inter-oviposition	Oviposition	Total longevity		
A .gossypii	20	♂	-	-	-	95.5±1.1 a^{A}	-	-
		♀	11.2±1.1 a^{A}	36.8±1.7 a^{A}	57.2±1.7 a ^{A}	104.2±1.2 a^{A}	489.3±3.3 c^{A}	8.55±0.79 c ^{A}
	24	♂	-	-	-	62.5±1.2 b^{A}	-	-
		♀	10.1±1.1 a^{A}	23.3±1.4 b ^{B}	37.9±1.2 b ^{A}	71.3±1.2 b^{A}	516.3±3.4 b^{A}	13.6±1.03 b^{A}
	28	♂	-	-	-	55.5±1.2 c^{B}	-	-
		♀	9.7±0.98 a^{A}	24.6±1.5 b^{B}	30.1±1.5 c^{B}	64.3±1.3 c^{B}	549.8±3.9 a^{B}	18.3±1.2 a^{A}
A. craccivora	20	♂	-	-	-	89.0±1.2 a^{B}	-	-
		♀	12.6±1.1 a^{A}	34.8±1.4 a^{B}	50.7±1.5 a^{B}	97.9±1.2 a ^{C}	459.7±2.8 c^{C}	9.1±0.71 c ^{A}
	24	♂	-	-	-	53.0±1.2 c^{B}	-	-
		♀	10.4±0.88 b^{A}	18.4±1.1 c^{C}	33.1±1.3 b^{B}	62.0±1.3 c^{A}	489.4±3.8 b^{B}	14.8±0.99 b^{A}
	28	♂	-	-	-	58.5±1.1 b^{A}	-	-
		♀	9.7±0.98 b^{A}	31.6±1.5 b^{A}	27.9±1.7 c^{C}	69.2±1.1 b^{A}	535.3±4.3 a^{C}	19.7±1.5 a^{A}
M. persicae	20	♂	-	-	-	93.5±1.1 a^{AB}	-	-
		♀	11.2±1.1 a^{A}	37.6±1.6 a^{A}	52.3±1.5 a^{B}	101.4±1.1 a ^{B}	468.3±3.1 c^{B}	9.0±0.69 c^{A}
	24	♂	-	-	-	64.5±1.1 b^{A}	-	-
		♀	10.1±1.1 a^{A}	29.3±1.4 b^{A}	32.9±1.3 c^{B}	72.4±1.3 b^{A}	471.3±3.4 b^{C}	14.3±1.02 b^{A}
	28	♂	-	-	-	57.0±1.2 c^{A}	-	-
		♀	9.0±1.1 a^{A}	18.8±1.5 c^{C}	36.0±1.5 b^{A}	63.8±1.4 c^{B}	580.3±3.8 a^{A}	16.1±1.2 a^{B}

[a]Means followed by the same small letter in a column between the three temperatures on each prey species or same capital letter in a column between the three prey species at the same temperature are not significantly different at the 1% level of probability (Duncan's Multiple Range Test).

Pre-oviposition, inter-oviposition, oviposition, and total longevity periods were 12.6, 34.8, 50.7, and 98.1 days, respectively at 20ºC, while these periods lasted 10.4, 18.4, 33.1, and 61.9 days at 24ºC, and 9.7, 31.6, 27.9, and 69.2 days at 28ºC, when the predator was reared on *A. craccivora* as a prey. There were significant variations between pre-oviposition, inter-oviposition, oviposition, and total longevity when the predator was reared at the three tested temperatures (Table 7). Male longevity was significantly shorter (69.2 days) at 28ºC than at 20ºC and 24ºC (89.0 and 53.0 days) when fed on the same prey. Concerning the fecundity of females, the average number of eggs per female was 459.7, 489.4, and 535.3, with significant differences among the three tested temperatures (Table 7). In addition, results in Table (8) showed that fecundity rate was significantly higher (19.2) at 28ºC than at 20ºC and 24ºC (9.1 and 14.8) when fed on the same prey.

The durations of pre-ovipositional, inter-ovipositional, ovipositional, and total longevity when the predator was reared on *A. craccivora* lasted 11.2, 37.6, 52.3, and 101.1 days, respectively at 20ºC, while these periods lasted 10.1, 29.3, 32.9, and 72.3 days at 24ºC, and 9.0, 18.8, 36.0, and 63.8 days at 28ºC. There were no significant differences in pre-ovipositional period among the three tested temperatures. In addition, there were significant variations between inter-oviposition, oviposition, and total longevity when the predator was reared at the three tested temperatures (Table 7). Male longevity was significantly shorter (57.0 days) at 28ºC than at 20ºC and 24ºC (93.5 and 64.5 days) when fed on the same prey. Concerning the fecundity of females, the average number of eggs per female was 468.3, 471.3, and 580.3 with significant differences among the three tested temperatures (Table 7). In addition, results in Table (7) showed that fecundity rate was significantly higher (16.1) at 28ºC than at 20ºC and 24ºC (8.9 and 14.3) when fed on the same prey.

6. Life table parameters

Data presented in Table (8) illustrate the life table parameters of *E. nigromaculatus* females when reared on *A. gossypii, A. craccivora*, and *M. persicae* at the three tested temperatures (20, 24, and 28ºC).

The mean generation time (T) was 67.68, 55.15, and 38.91 days at 20, 24, and 28ºC, respectively when reared on *A. gossypii*. The population of this predator could be doubled every 88.69, 71.39, and 5.09 days at 20, 24, and 28ºC, respectively when reared on *A. gossypii*. The value of gross reproductive rate (GRR) was higher (235.05) at 24ºC than at 20ºC and 28ºC (220.2 and 222.65). GRR refers to the sum of the average number of females produced per living female per day. This value is greater than the simple mean estimate of total fecundity per female per generation. The net reproduction rate (R_o), representing the total female births was 211.55 at 24ºC. This meant that the population of this predator would be able to multiply 211.55 times when fed on *A. gossypii* at the end of each generation. R_o was 198.18 at 20ºC and 200.39 at 28ºC. The value of the intrinsic rate of increase (r_m) was 0.0078, 0.0097, and 0.1362 when the predator was reared on *A. gossypii* at the three tested temperatures. The finite rate of increase (λ) was 1.0812, 1.1019, and 1.1459 at the three tested temperatures (20, 24, and 28ºC) that the population had the capacity to multiply 1.0812, 1.1019, and 1.1459 times per female per day. From data illustrated in Figure (1), it could be noted that the survivorship (*Lx*) for female age intervals was 90 at the three tested temperatures which means that most of eggs had developed to maturity, and death happened gradually after an extended ovipositional period. Maximum ovipositional rate per female per day (*Mx*) was 3.95 on 30th day, 5.85 on 14th day, and 7.00 on 10th day at the three tested temperatures (20, 24, and 28ºC), respectively (Fig. 1).

The mean generation time (T) was 67.80, 51.59, and 36.61 on *A. craccivora*, respectively at the three tested temperatures. The population of this predator could be doubled every 89.89, 6.84, and 4.72 days on *A. craccivora*, respectively at the three tested temperatures. The value of gross reproductive rate (GRR) was higher (241.35) at 28ºC than at 20ºC and 24ºC (207.05 and 206.75). The net reproduction rate (R_o), representing the total female births was 217.22 at 28ºC. This meant that the population of this predator would be able to multiply 217.22 times when fed on *A. craccivora* at the end of each generation. R_o was 186.35 at 20ºC and 186.08 at 24ºC. The value of the intrinsic rate of increase (r_m) was 0.0077, 0.1012, and 0.1469, when the predator was reared on *A. craccivora* at the three tested temperatures. The finite rate of increase (*λ*) was 1.0801, 1.1066, and 1.0583 at the three tested temperatures that the population had the capacity to multiply 1.0801, 1.1066, and 1.0583 times per female per day. From the data illustrated in Figure (2), it could be noted that the survivorship (*Lx*) for female age intervals was 90 at the three tested temperatures which means that most of eggs had developed to maturity, and death happened gradually after an extended ovipositional period. Maximum oviposition rate per female per day (*Mx*) was 4.15 on 12th day, 7.60 on 19th day, and 10.50 on 3rd day at the three tested temperatures, respectively (Fig. 2).

The mean generation time (T) was 67.34, 54.09, and 37.38 on *M. persicae*, respectively at the three tested temperatures. The population of this predator could be doubled every 88.98, 6.93, 4.57 days on *M. persicae*, respectively at the three tested temperatures. The value of gross reproductive rate (GRR) was higher (290.19) at 28^{o}C than at 20^{o}C and 24^{o}C (210.75 and 223.5). The net reproduction rate (R_o), representing the total female births was 290.15 at 28^{o}C. This meant that the population of this predator would be able to multiply 290.15 times when fed on *M. persicae* at the end of each generation. R_o was 189.68 at 20^{o}C and 223.50 at 24^{o}C. The value of the intrinsic rate of increase (r_m) was 0.0077, 0.1000, and 0.1516 when the predator was reared on *M. persicae* at the three tested temperatures. The finite rate of increase (*λ*) was 1.0810, 1.1051, and 1.1637 at the three tested temperatures that the population had the capacity to multiply 1.0810, 1.1051, and 1.1637 times per female per day. From data illustrated in Figure (3), it could be noted that the survivorship (*Lx*) for female age intervals was 90, 100, and 100 at 20, 24, and 28^{o}C, respectively which means that most of eggs had developed to maturity, and death happened gradually after an extended ovipositional period. Maximum ovipositional rate per female per day (*Mx*) was4.45 on 19th day, 6.30 on 9th day, and 9.65 on 19th day at the three tested temperatures (20, 24, and 28^{o}C), respectively (Fig. 3).

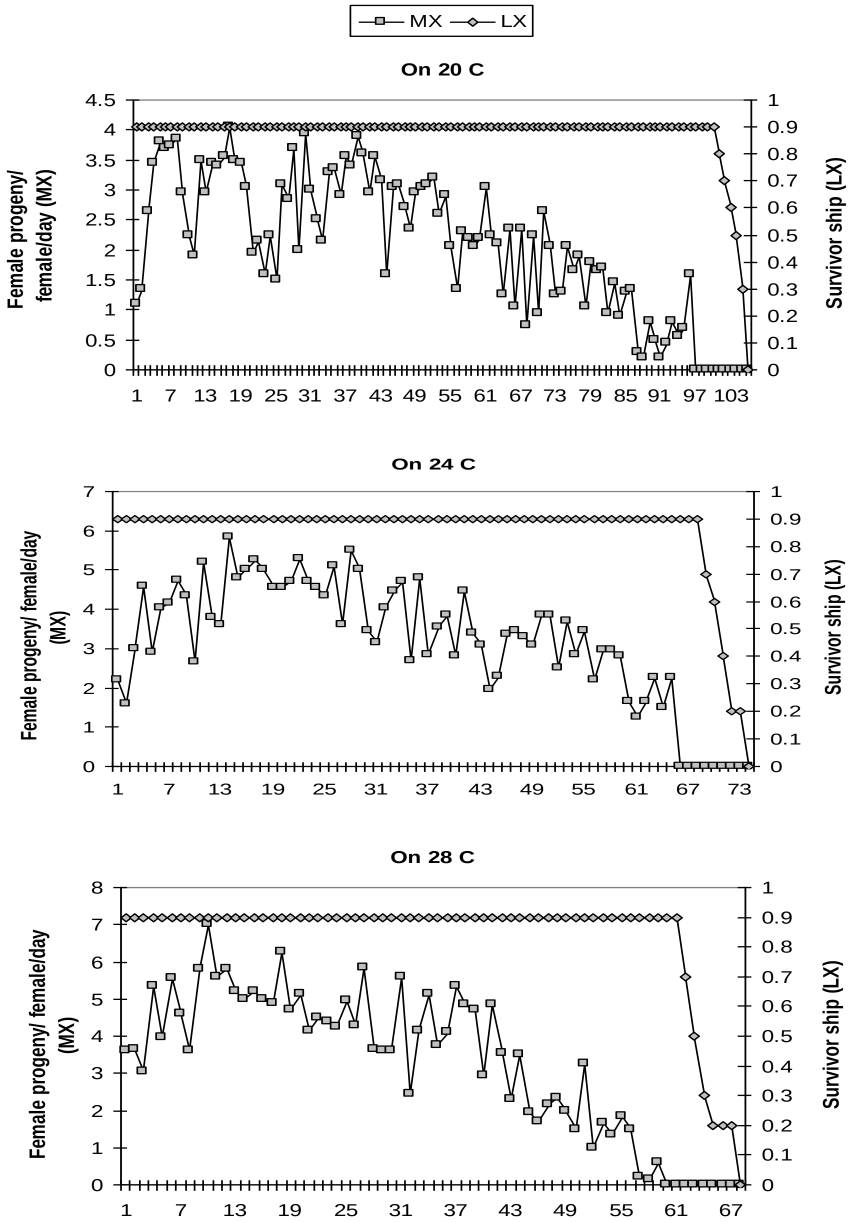

Figure (1). Age-specific fecundity (Mx) and survivorship (Lx) of *E. nigromaculatus* when reared on *A. gossypii* at different temperatures.

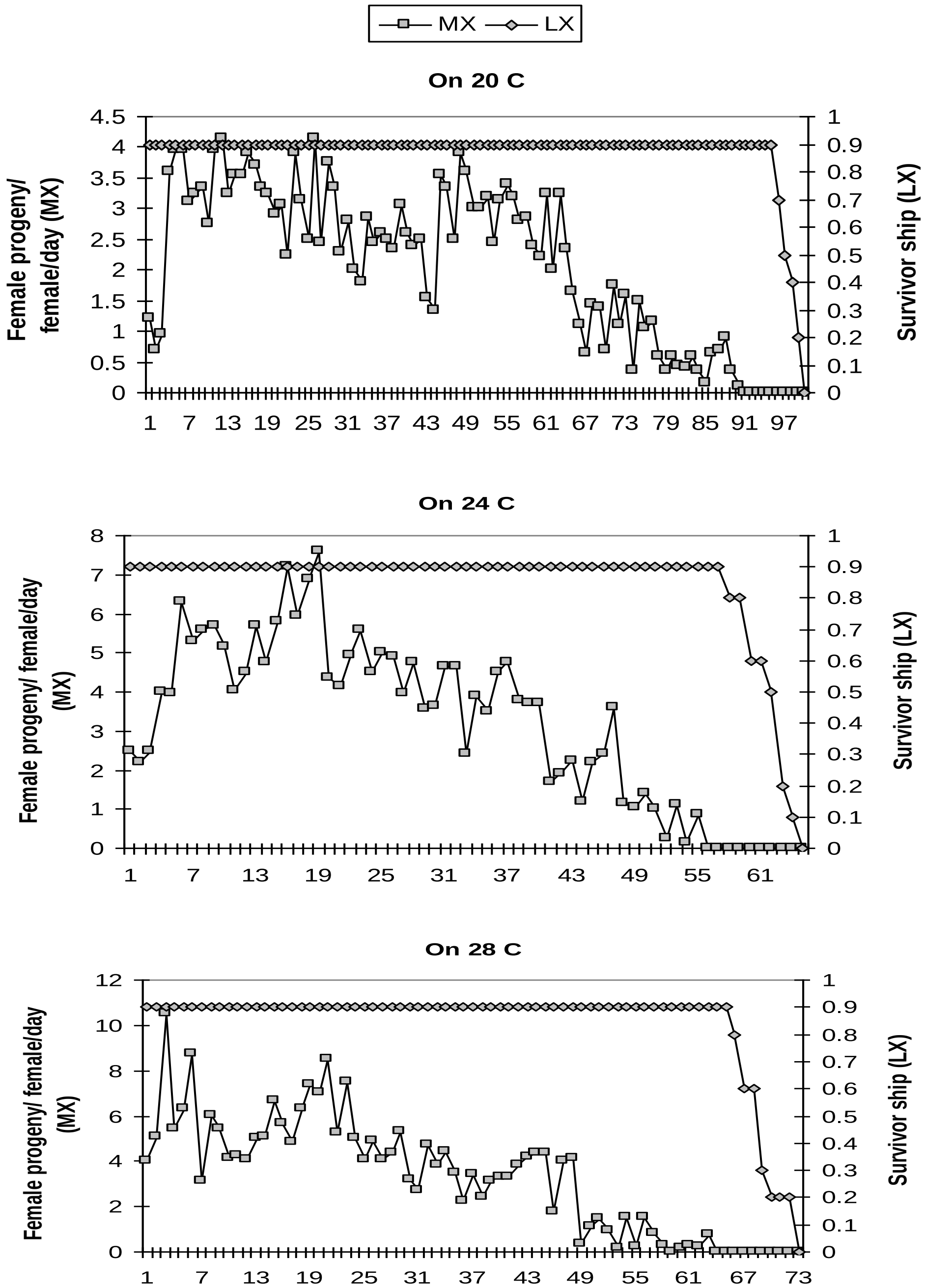

Figure (2). Age-specific fecundity (Mx) and survivorship (Lx) of *E. nigromaculatus* when reared on *A. craccivora* at different temperatures

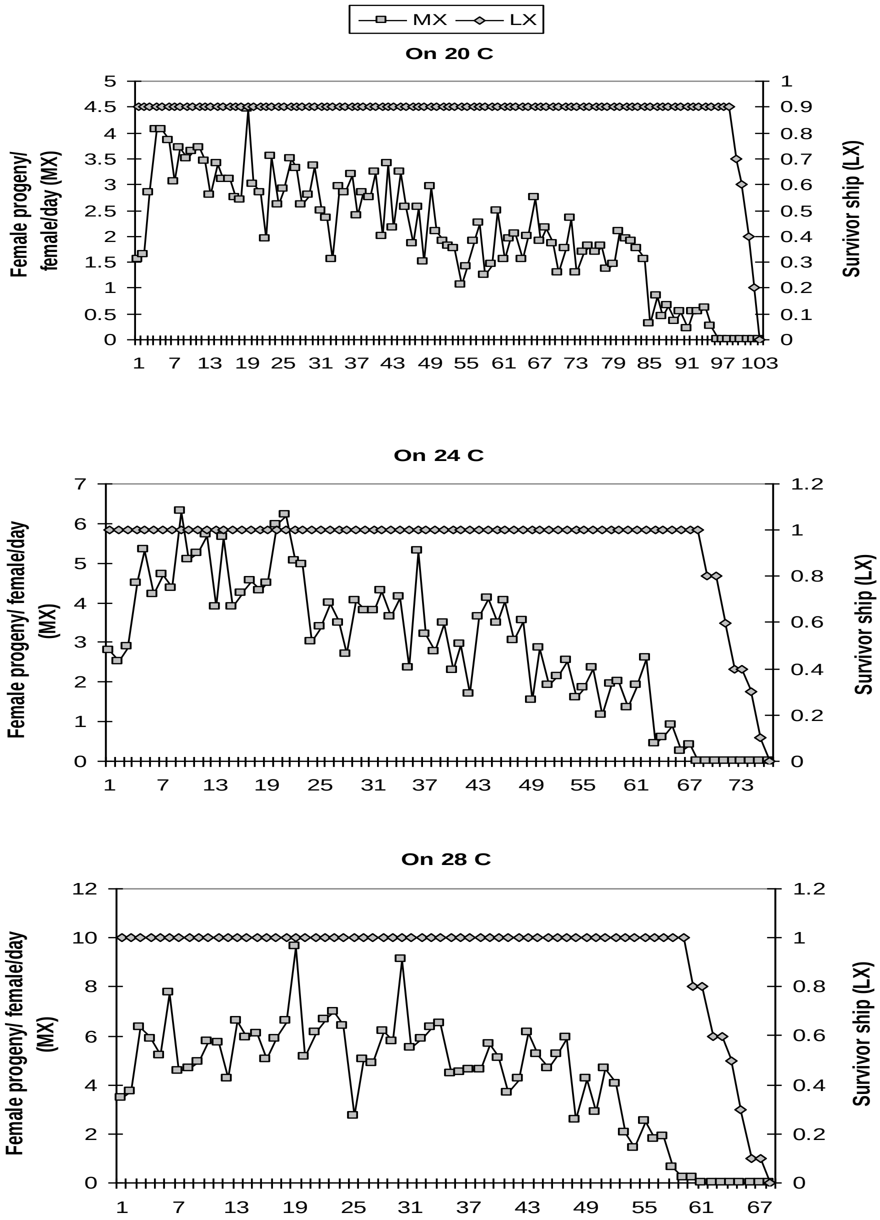

Figure (3). Age-specific fecundity (Mx) and survivorship (Lx) of *E. nigromaculatus* when reared on *M. persicae* at different temperatures.

Table (8). Life table parameters of *E. nigromaculatus* females when reared on different aphid species at different temperatures.

Prey Species	Temp. (°C)	Life table parameters					
		Mean generation time (T) (in days)	Doubling time (DT) (in days)	Gross reproductive rate (GRR)	Net reproductive rate (R_o)	Intrinsic rate of increase (r_m)	Finite rate of increase (λ)
A. gossypii	20	67.68	88.69	220.2	198.18	0.0078	1.0812
	24	55.15	71.39	235.05	211.55	0.0097	1.1019
	28	38.91	5.09	222.65	200.39	0.1362	1.1459
A. craccivora	20	67.80	89.89	207.05	186.35	0.0077	1.0801
	24	51.59	6.84	206.75	186.08	0.1012	1.1066
	28	36.61	4.72	241.35	217.22	0.1469	1.1583
M. persicae	20	67.34	88.98	210.75	189.68	0.0077	1.0810
	24	54.09	6.93	223.5	223.5	0.1000	1.1051
	28	37.38	4.57	290.19	290.15	0.1516	1.1637

DISCUSSION

Mass production of coccinellid predators in biological control programs requires huge numbers at low costs. It is desirable to choose the predator, which has short developmental times, a high survival rate, and a high reproductive capacity. The influence of *A. gossypii, R. maidis, M. avenae* Fab. and *A. nerii* as preys on biological aspects of *Exochomus flavipes* (Thnb.) was studied by Ghanim and El-Adl (1987). They found in the duration of the larval stage variation in the aphid species as it averaged 9.5 days when fed on *M. avenae* and 10.0 days on the other three aphid species. Female fecundity also varied from 790.4 to 507.8 eggs and a daily rate from 23.25 to 17.51 eggs when reared on *A. gossypii, R. maidis, M. avenae* and *A. nerii*.

In addition, Shao and Jin (1987) studied development temperature and thermal constant for the egg, larval and pupal stages of *Exochomus mongol* (Borousky) reared on scale insects in the laboratory. They mentioned that the initial development temperature and thermal constant (DD) for the eggs were 5.9 and 152.2°C, respectively. The corresponding values for larvae in the 1st to 4th instars and the pupa were 10.7 and 10.3, 12.2 and 38.5, 11.7 and 44.8, 15.1 and 51.9 and 15.6 and 43.6, respectively. Kiamfu *et al.* (1994) reported that total fecundity of *Exochomus falviventris* Madder females (up to 1165 eggs) and intrinsic rate of increase (up to 0.0094) increased with *E. kuehniella* as prey. Lotfalizedeh *et al.* (2000) stated that the incubation period of *Exochomus quadripustulatus* (L.) at 25°C when fed on the mealy bug, *Planococous vovae* (Nasanov) averaged 5.9 days, the 1st, 2nd, 3rd and 4th larval instars averaged 3.37, 2.93, 6.17 and 8.50 days, respectively and larval stage period averaged 20.97 days, pupal period lasted 6.13 days and the total developmental time averaged 33.00 days.

Atlihan and Kaydan (2002) studied the development, survival, and fecundity of *E. nigromaculatus* at 25°C. Developmental time from egg to adult was 6.7 days for E. nigromaculatus. Mortality rate was 25.7%. Duration of oviposition period was 75.3 days. Total number of eggs per female was 428.5. According to life table parameters, net reproduction rate per female, intrinsic rate of increase, and mean generation time were 157.2, 0.134, and 37.7. Also, Atlihan and Özgökçe (2002) reported that developmental time of

E. nigromaculatus from egg to adult ranged from 22.4 days at 20°C to 10.6 days at 35°C, and required 278 degree-days above a threshold estimated to be 9.11°C, when reared on *Hyalopterus pruni*. Survival was highest at 25°C and lowest at 35°C. Longevity of females declined significantly with increasing temperatures, ranging from 120.7 days at 20°C to 46.6 days at 35°C. Mean generation time became shorter with increasing temperatures. The intrinsic rate of increase of individuals kept at 30°C was significantly greater than that of individuals kept at the other temperatures tested. They showed that the optimal temperature for population growth of *E. nigromaculatus* was 30°C.

El-Serafi (2006) reared *E. nigromaculatus* on *Aphis nerii* (Boyer de Fonsconlonbe), *Rhopalosiphum maidis* (Fitch**)** and *Macrosiphum pisi* (Harris) under laboratory conditions. The durations of larvae were 17.1, 13.1 and 13.7days when reared on *A. nerii*, *R. maidis* and *M. pisi*, respectively. Longevity of the female averaged 49.00, 54.00 and 47.80 days when reared on the three tested aphid species. The fecundity of the female was 83.00, 906.00 and 211.60 eggs by rearing on the three previously aphid species. Also, Mohamed *et al.* (2008) reported that total developmental time of *E. nigromaculatus* was differed significantly when reared on *M. pisi, R. maidis*, *Aphis daurantae* Theobld and *A. nerii*. Mortatality percentage from egg hatching to adult emeregence was 9.70% when fed on *M. pisi* to15.8% on *A. nerii.* They found that the aphid species had significant effect on the longevity and fecundity of *E. nigromaculatus*.

In conclusion, *E. nigromaculatus* had a shorter developmental time of immature stages, a relatively higher survivorship, a moderately longevity, a higher fecundity, and a higher intrinsic rate of natural increase (r_m) Therefore, it has a fine potential for mass rearing and periodic release. This predator presents excellent opportunity of a biological control agent that could be manipulated in an integrated pest management (IPM).

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الإحتياجــات الحراريـــة ، المقـــاييس البيولوجيـــة وجـــداول الحيـــــاة للمفتـــرس *Exochomus nigromaculatus* (Goeze) عند تربيته على ثلاثة أنـواع من المنّ

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تم دراسة تأثير درجات الحرارة ٢٠ ، ٢٤ ، ٢٨ °م وكذلك أنواع المنّ الثلاثـة: منّ القطن ، منّ اللوبيا ومن الخوخ الأخضر على كل من فترات النمو وفهرس النمـــو ومعدل النمو والبقاء وفتـرات الحيـاة ومقـاييس جـداول الحيـــاة للمفتـرس ***Exochomus nigromaculatus* (Goeze)** وكذلك تم دراسة العلاقة بين كل من معدل النمو ودرجات الحرارة المدروسة لتحديد كل من الوحدات الحرارية المتجمعة وأقل حد حرارى للنمو.

أوضـحت النتـائج وجـود فـروق معنويـة فـى طـول فتـرة النمـو للأطـوار غيـر الكاملـة للذكور والإنـاث للمفتـرس عنـد التربيـة علـى درجـات الحـرارة المختبـرة علـى الفـرائس الثلاثـة. بينمـا أظهـرت نتـائج التحليل الإحصائى عدم وجود إختلافات معنوية فى فترة النمو للمفترس عند التربية على أنـواع المـن على نفس درجة الحرارة. كما أوضحت النتائج أن فهرس النمو ومعدل النمو كان مرتفعاً عند التربيـة على درجات الحـرارة ٢٨ °م بالمقارنة بدرجتى ٢٠ °م ، ٢٤ °م وذلك عند التربية علـى أنـواع المنّ المختبرة كما إتضـح أن نسبة البقاء كانت مرتفعةً على درجتـى حـرارة ٢٨ °م ، ٢٤ °م بالمقارنـة بدرجة حرارة ٢٠ °م وذلك عند التربية على منّ الخوخ الأخضر بالمقارنة بالتربية على كل من منّ القطن ومنّ اللوبيا.

أشارت النتائج أن الوحدات الحرارية المتجمعة واللازمة لنمو البيض ووصـوله إلـى طـور الحشـرة الكامـل هـى ٢٦٣,١٦ علـى الفـرائس الثلاثـة المدروسـة. وقـد أظهـرت النتـائج أنـه لايوجـد إختلاف معنوى بين فترة ماقبل وضع البيض عندما تم تربية المفترس علـى درجـات الحـرارة الثلاثـة ووجد أنه يوجد فرق معنوى بين طـول فتـرات الحيـاة وفتـرات وضـع البـيض علـى درجـات الحـرارة المختبرة. أشارت النتائج أن فترة الحياة للذكور كانت قصيرة على درجة حرارة ٢٨ °م بالمقارنـة بدرجتى ٢٠ °م ، ٢٤ °م وذلك على نفس الفريسة. كمـا إتضـح أن معدل وضـع البـيض كـان مرتفعـاً على درجة حرارة ٢٨ °م بالمقارنة بدرجتى ٢٠ °م ، ٢٤ °م .

كما أظهرت النتائج أيضـا أن قيم جدول الحياة المحسوبة لمتوسط فترة الجيل (T) والزمن اللازم للتضـاعف (DT) كانت أقصرعند التربيـة علـى درجـة حـرارة ٢٨ °م بالمقارنـة بـدرجتى ٢٠ °م ، ٢٤ °م . وكذلك كانت قيم معامل التضاعف (R_o) ، معدل التكاثر (GRR) ، معدل الزيادة الطبيعى (r_m) ، ومعدل الزيادة النهائى (λ) أعلى عند التربية على درجـة حـرارة ٢٨ °م بالمقارنـة بـدرجتى ٢٠ °م ، ٢٤ °م .

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