BIOLOGICAL ASPECTS AND LIFE TABLES OF THE COCCINELLIDS PREDATOR *RODOLIA CARDINALIS* AND ITS PREY *ICERYA SEYCHELLARUM* (HOMOPTERA: MARGARODIDAE).

SAYED, A. AHMED[1]; ABD EL-HAKAM A. EL-SAEAEDY[2]; HAMDY A. MOHAMED[2]; HELAL A. HELAL[2] AND ATEF M.M. SAYED[3]

[1]*Faculty of Environ. Agric. Sci., Suez Canal univ., El-Arish, Egypt.*
[2]*Faculty of Agric., Al-Azhar Univ., Egypt*
[3]*Plant Protection Research Institute, Agric. Res. Center, Egypt.*

ABSTRACT

Certain biological aspects of the Seychelles fluted scale, *Icerya seychellarum* and vedallia beetle, *Rodalia cardinalis* were studied at laboratory under three degrees of constant temperature 20°, 25° and 30°C.

Life table parameters; survivorship (lx), fecundity (mx), gross reproductive rate (GRR), net reproductive rate (Ro), the intrinsic rate of increase (rm), generation time (Gt), population-doubling time (Dt) and finite rate of increase (λ) for prey-predator system were calculated. The intrinsic rate of increase (rm) of the prey was lower than that of the predator at the three investigated temperature degrees 20°, 25°C and 30°C, with the proportion of 4.33, 2.91 and 2.98, respectively with an average of 3.41. The food capacity of the predator was 14.38 individuals/day. The mathmetical value of population predatism power (PPP) of the predator was 49.02. This means that one individual of the predator *R. cardinalis* can successfully control 49.02 individuals of the mealybug *I. seychellarum.*

INTRODUCTION

The margarodid mealybug, seychelles fluted scale, *Icerya seychellarum* (Westwood) could be considered as one of the main pests which cause serious damage to many economic horticultural plants in Egypt (Assem *et al.*, 1991). It is usually controlled by the use of some chemical insecticides such as, Malathion, Cidial, Actellic and mineral oils (El-Borollosy *et al.*, 1990 and Negm *et al.*, 2000)

In recent years, considerable changes have been happened in attitude towards the use of chemical pesticides in agriculture. Public awareness, concerning the quantities and types of these chemicals and their potential impact on the environment were increased. The effect of chemical insecticides on human health has led to more stringent regulations on their use. Resistance of some pest species to many pesticides is not new problem. Cumulatively, these disadvantages provide a strong incentive to find alternative ways of controlling pests. Consequently, interest has focused on biological control as alternatives to chemicals. The predator vedalia beetle, *Rodalia cardinalis* (Mulsant) (Coleoptera: Coccenellidae) was identified as the most suitable agent which play a considerable role as a biological control agent in integrated pest management programs (Ragab, 1995; Grafton-Cardwell andGu; Causton *et al.*, 2004; Hirose, 2006 and Frank and McCoy 2007).

R. cardinalis, is a primary natural enemy regulating populations of cottony cushion scale, *Icerya purchasi* Maskell (Homoptera: Margarodidae) in California since 1888. It provides excellent biological control owing to its high reproduction rate, rapid development, and host specificity (Caltagirone and Doutt, 1989). In Egypt, it was established since it had been introduced in 1902 to control the cottony cushion scale *Icerya purchasi* (Hamed and Saad, 1989).

The present work was set up to estimate the effective numbers of the predator *R. cardinalis*, to achieve sufficient control to the pest, *I. seychellarum* cross the gate of some biological aspects and life table parameters for each of the predator and the prey.

MATERIAL AND METHODS

I. Maintenance of the cultures

I.1. Mass rearing of mealybug culture

The rearing was carried out at Plant Protection Department of Ismailia Agricultural Research Station. Leaves and branches of mulberry tree heavily infested with mealybugs particularly *I. seychellarum* were collected from different areas in Ismailia Governorate and placed on seedlings of ficus, *Ficus nitida* one-year old grown in clay pots (20 cm diameter). The seedlings were isolated inside cheese cloth cages (60x 60 x 120 cm.) away from any pesticides contamination or insect infestation. The culture of mealybug were kept under controlled greenhouse condition, 25 ± 2°C. 60±5 % R.H. and photoperiod of LD 12:12 by using fluorescent tubes of 40 watt.

I.2. Mass rearing of predator culture

Adults of the predator vedalia beetle, *Rodolia cardinalis* were collected from the fields and kept in glass tubes (4x12 cm.) covered with muslin. Each tube was provided daily with ficus leaves heavily infested with mealybug, *I. seychellarum* as a sufficient food supply of prey. Leaves carrying-newly-deposited eggs of the predator were collected and kept in petri dishes (9 cm. diameter). The eggs examined daily until hatching.

Directly after hatching, larvae were transferred singly into plastic tubes (3.5x7 cm.), where they provided with sufficient leaves infested with prey. The amount of food was increased with the larval development until pupation. Pupae were kept in glass tube (4 x 12 cm.) covered with muslin held in place by rubber band till adults emergence. The rearing was maintained for six months to obtain sufficient number of the predators.

II. Experimental procedures

Biological studies on seychelles fluted scale, *I. seychellarum* and its predator; *R. cardinalis* were carried out under three degrees of constant temperatures, 20°, 25° and 30°C.

Ten individuals one-day-old of *I. seychellarum* ovisacs were randomly collected from ficus seedlings of mealybug culture. From each ovisac, twenty eggs were randomly removed with a piece of ovisac intact. At the beginning of the experiment 160, 136, and 136 eggs of *I. seychellarum* were started at 20°, 25°, and 30°C, respectively. Each egg was placed individually on sprouted potatoes in glass jars (10cm. diameter). Just after hatching, the glass jars were covered with black cotton cloth for 24 hours to encourage the crawlers to settle and start feeding. The different developmental stages were observed daily. Observations were conducted with the aid of a stereomicroscope.

To insure copulation couple of adult insect of the predator *R. cardinalis*, one male and one female were isolated each in glass tubes (4x12 cm). Each tube was covered with a piece of thin muslin which was kept in place by means of rubber band and provided with ficus leaves heavily infested with *I. seychellarum* for feeding the beetles with a sufficient supply of prey. The adults were let to lay eggs for an overnight to oviposition (as zero time), and then removed. At the beginning of the experiment 68, 133, and 60 eggs were started at 20°, 25°, and 30°C, respectively. Each egg was carefully placed in 4 cm diameter Petri dish with the aid of a camel hair brush. Eggs were examined daily.

Newly hatched larvae were transferred singly into glass tubes (3x8 cm.). The tubes were covered with a piece of thin muslin held in place by rubber band. Each tube was provided daily with ficus leaves heavily infested with the prey, *I. seychellarum* more than it may need. Data on developmental stages were recorded daily. Exuvial and fecal matter were promptly removed. The emerged adults were arranged into pairs, and each pair was put in glass tubes (4x12cm). Each tube was covered with a piece of thin muslin which was kept in place by rubber band and provided with ficus leaves heavily infested with *I. seychellarum* for feeding. The laid eggs of *R. cardinalis* were counted and destroyed daily.

The experiment was terminated when all tested females each of *I. seychellarum* and *R. cardinalis* were died. The experiment was carried out under three constant temperature degrees 20°, 25° and 30°C.

Results obtained were subjected to statistical analysis by using analysis of variance. When F value was significant L.S.D. was calculated to separate between means.

Life table procedures (Birch, 1948 and Howe, 1953) were followed in analyzing data according to the following parameters in Table (1).

TABLE (I)

Definition and formula for life table parameters.

Symbol	Definition	Formula
x	Age of individuals.	-----
lx	Probability of an individual surviving to age x.	-----
mx	Reproductive expecting of a female at age x.	
Ro	Net reproductive rate, (number of daughters that replace average females in course a generation).	$\sum$ lx mx
Gt	Mean generation time (mean time elapsing between birth of parents and the birth of offspring).	$\sum$ x. mx lx /Ro
rm	Intrinsic rate of increase, (number of individuals produced per unit time).	(Log e^{Ro}) / Gt.
λ	Finite rate of increase, (number of individuals added to the population per female per day).	e^{rm}
Dt	Days for population to double.	(Log e^2) / Rm
e	Constant	e = 2.72

III. Predatism capacity

Twenty new hatched predator larvae were kept separately in glass tubes (3x8 cm) and provided daily with fixed number of the new adult prey exceeding the need of the predator by a fine camel hair brush. The numbers of consumed prey individuals were recorded daily until the death of the predator, and then predatism capacity was calculated (according to Ahmed and El-Adawy, 2002).

RESULTS AND DISCUSSION

I. Duration of developmental stages of *I. seychellarum*

I.1. Egg stage

Results in Table (2) showed that incubation period of the eggs were 14.43±1.09, 8.53±0.43 and 7.87±0.42 days at 20°, 25° and 30°C, respectively. It is obvious that the incubation period was longer at 20° than that at each of 25° and 30°C. No significant difference between incubation periods in each of 25° and 30°C, however significant effect was noticed at 20°C.

I.2. Nymphal stage

Data presented in Table (2) showed the durations of the three nymphal instars at the three tested temperature degrees. It was obvious that nymphal duration was decreased with temperature increase of the three tested temperature degrees. The longest duration averages for first, second and third nymphal instars at 20°C were 36.50±0.88, 20.93±0.94, and 22.60±0.88 days, respectively, whereas the shortest averages were achieved at 30°C 16.33±0.50, 11.93±0.65, and 19.43±0.78 days, respectively. The nymphal duration values at 25°C come between the duration values at 20°C and °C. It were 21.47±0.67, 13.57±0.57 and 20.13±0.41days, respectively.

The mean durations of the whole nymphal stage were 80.0±2.02, 55.17±0.81, and 47.7±1.04 at 20°, 25°, and 30°C, respectively. It could be concluded that the duration of nymphal stage was found to decrease as the corresponding temperature increase. The three temperature degrees revealed highly significant effects on the three nymphal durations.

I.3. Adult female longevity

Data given in Table (2) showed the adult longevity values at the three tested temperature degrees. The longest mean longevity was 134.23±6.42 days occurred at the lowest temperature 20°C, while the shortest mean longevity was 88.87± 6.38 days occurred at 25°C. The longevity at 30°C was 96.0±6.02. It is obvious that the three constant temperature degrees significantly affected on adult longevity.

I.4. Oviposition periods & Fecundity of adult female

Results of statistical analysis revealed that the pre-oviposition, oviposition and post-oviposition periods significantly affected according to the prevailing temperature (Table, 2).

TABLE (II)

Mean duration of different developmental stages of *Icerya seychellarum* at three degrees of constant temperatures.

Temp. °C	Mean duration in days ± s.e. (range)										
	Egg stage	Nymphal instars			Mean total nymphal stage	Adult female			Longevity of adult female	No. of Deposited eggs/female	Total duration
		1st nymphal instar	2nd nymphal instar	3rd nymphal instar		Pre-oviposition peroid	Ovi-position period	Post-oviposition peroid			
20°	14.43±1.09 (7-24) a	36.50±0.88 (27-46) a	20.93±0.94 (13-31)a	22.60±0.88 (12-31)a	80.03±2.02 (58-103)a	101.90±6.66 (29-132)a	25.37±2.32 (1-56)b	6.97±1.64 (0-45)b	134.23±6.42 (54-179) a	115.27±8.98 (12-214) b	228.70±6.70 (153-274) a
25°	8.53±0.43 (5-14) b	21.47±0.67 (12-27) b	13.57±0.57 (10-21)b	20.13±0.41 (16-25)b	55.17± 0.81 (49-66)b	26.87±1.84 (14-54)b	49.10±4.46 (11-95)a	12.90±2.27 (1-40) a	88.87± 6.38 (32-162)b	155.70± 12.26 (38-286)a	152.57± 6.79 (95-238)b
30°	7.87±0.42 (5-12) b	16.33±0.50 (10-21) c	11.93±0.65 (7-20)b	19.43±0.78 (13-27)b	47.70±1.04 (39-57)c	25.37±2.56 (14-58)b	56.50±4.36 (11-97)a	14.13±1.91 (3-38)a	96.00±6.02 (33-142)c	164.23±15.35 (16-391)a	151.57±6.51 (86-200)b
L.S.D.	1.99	2.03	2.09	2.03	10.56	11.77	10.92	5.48	14.67	35.12	18.64

- Means within a column followed by the same letter are not significantly different (P> 0.05), least significant differences at 5% level of significance was used.

The pre-oviposition period was estimated as the time elapsing between date of female emergence and date of depositing the first egg. Means of pre-oviposition period were 101.90, 26.87, and 25.37 days at 20°, 25°, and 30°,C respectively.

Means of oviposition period were 25.37, 49.10, and 56.50 days at the previously mentioned temperature respectively. These results indicate that oviposition period increases with increase of temperature.

The post-oviposition period was estimated as the time elapsed between the date of lasted deposited egg and the date of female death. The means of post oviposition period were 6.97±1.64, 12.97±2.27 and 14.13±1.91 days at 20°, 25° and 30°C, respectively. This period was found to be relatively shorter than other two periods. Results of statistical analysis revealed that this period was significantly affected by corresponding temperature.

The reproductive potentially was expressed as total number of deposited eggs per female during its longevity. Data in Table (2) showed the mean numbers of deposited eggs per female were 115.28±8.98 eggs/female at 20°C, whereas at 25°. and 30°C, it were 155.70 ±12.26 and 164.23±15.3 eggs/female, respectively, without significant difference between both means. It is obvious that the female fecundity was significantly affected by constant temperature. It could be concluded that temperature range between 25-30°C is considered as the optimum zone temperature for mealybug deposition.

1.5. Total duration

Total duration of *I. seychellarum* was estimated as the whole time in days elapsed between the first deposited egg up to the death of adult female of mealybug. This period could be considered as a generation for this insect. Duration of generations was investigated under the three degrees of constant temperature.

Results Obtained are given in Table (2) showed that the maximum length of generation was 228.70 ± 6.70 days at 20°C, while shortest duration of generation was 151.57±6.51 days at 30°C. The total duration value at 25°C come between the two former values. It was 152.57±12.26 days.

II- Duration of different developmental stages of *R. cardinalis*

II.1. Egg stage

Results Obtained for the effects of the three constant temperature degrees on incubation period of eggs are given in Table (3). The incubation period decreased significantly with the increase in temperature. The means of incubation period of the three tested degrees of temperature were 5.05±0.08, 4.02±0.0.05, and 3.87±0.04 days at 20°, 25° and 30°C, respectively. It is obvious that the incubation period was longer at 20°C than that at each of 25° and 30°C. These results revealed that at 25° and 30°C had no significant effects on incubation period of eggs.

II.2. Larval stage

Data presented in Table (3) showed the durations of the four larval instars at the three tested temperature degrees. It was obvious that larval stage duration was decreased with temperature increase.

The longest duration averages for first, second, third and forth larval instars at 20°C were 4.49±0.11, 4.50±0.14, 3.87±0.16 and 6.42±0.23, respectively, whereas the shortest averages were achieved at 30°C 2.68±0.09, 2.20±0.06, 3.03±0.05 and 4.19±0.11, respectively. The larval instars of duration values at 25°C come between the duration values at the aforementioned temperature degrees. These means were 2.69±0.03, 2.68±0.05, 3.25±0.05 and 4.85±0.08, respectively.

The mean duration of the larval stage varied from 24.33±0.69 days at 20°C to 12.11±0.31 days at 30°C. The mean duration value of the larval stage was 13.47±0.19 days at 25°C and come between the duration values at the aforementioned temperature degrees.

It could be concluded that the duration of larval stage was found to decrease as the corresponding temperature increase. The three temperature degrees revealed highly significant effects on the forth larval durations.

II.3. Pre-pupal stage

The mean duration of the pre-pupal stage of vedallia beetle was the shortest of developmental stages. It was greatly affected by the prevailing degrees of temperature. The longest mean duration were 5.10±0.17 days at

20°C, the shortest duration was 1.56±0.07 days at 30°C. Analysis of variance showed highly significant effects of the three constant degrees of temperature on pre-pupal duration.

II.4. Pupal stage

Data in Table (3) showed the mean durations of pupal stage at the three tested temperature degrees. The longest mean pupal duration was 10.25±0.45 days occurred at 20°C, while the shortest mean duration was 5.58±0.15 days at 30°C. The results revealed that the three constant temperature degrees significantly affected on the pupal duration at each of the corresponding degrees of temperature.

TABLE (III)

Mean duration of different developmental stages of *Rodalia cardinalis* at three degrees of constant temperatures.

Temp. °C	Mean duration in days ± s.e. (range)								
	Egg stage	Larval instars				Mean total larval stage	Prepupal stage	Pupal stage	Total
		1st larval instar	2nd larval instar	3rd larval instar	4th larval instar				
20°	5.05±0.08 a (4-7)	4.49±0.11 a (4-6)	4.50±0.15 a (2-4)	3.87±0.16 a (3-5)	6.42±0.23 a (4-8)	24.33±0.69 a (19-31)	5.10±0.17 a (3-6)	10.25±0.45 a (7-18)	39.68±1.38 a (33-62)
25°	4.02±0.05 b (3-5)	2.96±0.02 b (2-4)	2.68±0.05 b (2-4)	3.25±0.05 b (3-5)	4.85±0.08 b (3-6)	13.47±0.19 b (10-19)	2.27±0.07 b (1-4)	6.41±0.08 b (5-10)	26.44±0.39 b (19-38)
30°	3.87±0.04 b (3-4)	2.68±0.09 b (1-4)	2.20±0.06 b (1-3)	3.03±0.05 b (1-4)	4.19±0.11 b (2-7)	12.11±0.31 c (5-18)	1.56±0.07 c (1-2)	5.58±0.15 b (4-8)	23.12±0.57 c (13-32)
L.S.D.	0.56	0.64	0.53	0.6	0.92	1.31	0.63	1.62	2.12

- Means within a column followed by the same letter are not significantly different (P> 0.05), least significant differences at 5% level of significance was used.

II.5. Adult longevity

Results Obtained are given in Table (4). The longest means longevity for males and females were 27.08±4.45 and 52.36±6.28 days, respectively, occurred at the lowest temperature 20°C., while the shortest means longevity 11.06±1.59 and 17.38±1.70 days for male and female, respectively, occurred at 30°C. These results showed that the three constant temperature degrees significantly affected onadult longevity.

II.6. Fecundity of adult female

Females passed through three periods until their death. These are the pre-oviposition, oviposition, and post-oviposition periods. The durations of these periods fecundity were investigated under the three degrees of constant temperature and are given in Table (4) .

Means of pre-oviposition period were 3.60±0.45, 2.36±0.21 and 2.13±0.20 days at 20°, 25°, and 30°C, respectively. Results of statistical analysis revealed that temperature significantly affected on the pre-oviposition period.

Means of oviposition period were 33.28±4.40, 19.76±0.05, and 9.00±0.97 days at the previously mentioned temperatures, respectively.

Statistical analysis showed that this period were highly significant affected according to the prevailing temperature.

These results indicate that oviposition period decreases with increase of temperature. The means of post-oviposition period were 15.48±3.45, 4.56±0.53, and 6.25±1.91 days at 20°, 25°, and 30°C, respectively.

Data in Table (4) showed the female fecundity was significantly affected by prevailing constant temperature. At 20°C number of deposited eggs ranged between 15-244 eggs with a means 136.12±15.95 eggs/female, while at 25°C. it ranged between 27-352 eggs with a means 150.80±16.14 eggs/female. At 30°C numbers of deposited eggs ranged between 9-162 eggs with a means 70.06±8.03 eggs. It could be concluded that temperature ranged between 20-25°C is considered as the optimum zone temperature for predator reproductive potentiality. These results are in close agreement with those by Hamed and Saad (1989), Ragab (1995), Osman (2005), Grafton-Cardwell *et al.*, (2005) and Hirose (2006).

TABLE (IV)

Mean duration of different developmental stages of *Rodalia cardinalis* at three degrees of constant temperatures.

Temperature °C	Adult Females				Adult longevity	
	Pre-oviposition peroid	Ovi-position peroid	Post-oviposition peroid	No. of deposited eggs / female	Female	Male
20°	3.60±0.45 a (1-8)	33.28±4.40 a (7-79)	15.48±3.45 a (0-67)	136.12±15.95 a (15-244)	52.36±6.28 a (10-121	27.08±4.45 a (3-86)
25°	2.36±0.21 b (1-4)	19.76±0.05 b (6-30)	4.56±0.53 b (1-10)	150.80±16.14 a (27-352)	27.30±2.03 b (12-49)	18.28±1.84 b (3-36)
30°	2.13±0.20 b (1-4)	9.00±0.97 c (4-19)	6.25±1.29 b (1-21)	70.06 ± 8.03 b (9-162)	17.38±1.70 b (7-34)	11.06±1.59 b (2-27)
L.S.D	0.84	7.48	5.78	37.25	10.61	7.76

- Means within a column followed by the same letter are not significantly different (P> 0.05), least siginficat differences at 5% level of significance was used.

III- Life tables of *I. seychellarum* and its predator *R. cardinalis*

III.1. Intrinsic mortality

The life expectancy and actual population size, which have been dead during different life stage, were recorded throughout one generation. Percentages of real and intrinsic mortalities were calculated.

Obtained results are given in Tables (5 and 6) showed that mortality percentages through different stages of prey and predator differed from stage to another according to changes in the prevailing conditions.

TABLE (V)

Intrinsic mortality of *Icerya seychellarum* reared at three constant temperature degrees.

Temperature °C	Insect stage (x)	No. of living individuals at the beginning of age interval (lx)	No. of dying during the age interval (dx)	% apparent mortality (dx*100/ lx)	% intrinsic mortality •
20°	Eggs	160	37	23.13	14.45
	Nymphs	123	54	43.90	27.44
	adults	69	0	0.00	0.00
25°	Eggs	136	15	11.03	8.11
	Nymphs	121	32	26.45	19.45
	adults	89	0	0.00	0.00
30°	Eggs	136	19	13.97	10.27
	Nymphs	117	23	10.26	7.54
	adults	94	0	0.00	0.00

• % Intrinsic mortality = % apparent mortality *100/no. of eggs at the beginning

Data in Table (5) showed that at the beginning of the experiment 160, 136, and 136 eggs of *I. seychellarum* were started at 20°, 25°, and 30°C, respectively, while 69, 89 and 94 adults were obtained at the end of the generation at the three tested temperature degrees. Most percentage of real mortalities occurred throughout nymphal stage being 43.90, 26.45, and 10.26 at 20°, 25° and 30°C, respectively; while no mortality occurred throughout adult stage at the three tested temperature degrees.

Percentage of intrinsic mortalities was estimated throughout life stages based upon the number of individual (eggs) at the beginning of generation. The percentage of intrinsic mortality was the highest in the nymphal stage (27.44%) at 20°C compared to 19.45 and 10.27% at 25° and 30°C, respectively. These mortality percentages were probably due to biotic and abiotic factors prevailing throughout this generation.

Concerning *R. cardinalis*, the obtained results in Table (6), showed that at the beginning of the experiment 68, 133, and 60 eggs were started, while 42, 110 and 50 adults were obtained at the end of the generation at 20°, 25°, and 30°C, respectively. Most percentage of real mortalities occurred throughout larval stage being 22.81, 3.88 and 8.33%, respectively, while no mortality occurred throughout adult stage at 20°, 25° and 30°C, respectively.

TABLE (VI)

Intrinsic mortality of *Rodolia cardinalis* reared at three constant temperature degrees.

Temperature °C	Insect stage (x)	No. of living individuals at the beginning of age interval (lx)	No. of dying during the age interval (dx)	% apparent mortality (dx*100/ lx)	% Intrinsic mortality •
20°	Eggs	68	11	16.18	23.79
	Larvae	57	13	22.81	33.54
	Pre-pupae	44	0.0	0.00	0.00
	Pupae	44	2	4.55	6.68
	Adults	42	0.0	0.00	0.00
25°	Eggs	133	2	1.50	1.13
	Larvae	129	5	3.88	2.91
	Pre-pupae	124	7	5.65	4.24
	Pupae	117	7	5.98	4.50
	Adults	110	0.0	0.00	0.00
30°	Eggs	60	0.0	0.00	0.00
	Larvae	60	5	8.33	13.89
	Pre-pupae	55	3	5.45	9.09
	Pupae	52	2	3.85	6.41
	Adults	50	0.0	0.00	0.00

• % Intrinsic mortality = % apparent mortality *100/no. of eggs at the beginning

Percentages of intrinsic mortalities were estimated throughout life stages based upon the number of individual (eggs) at the beginning of generation. The percentage of intrinsic mortality was the highest in the larval stage (33.54%) at 20°C compared to 2.91 and 13.89 at 25° and 30°C, respectively. These mortality percentages were probably due to biotic and abiotic factors prevailing throughout this generation. The highest percentage of mortality throughout larval stage was probably due to competition for food during this active stage.

III.2. Life table parameters

Data in Table (7) summarized life table parameters of *I. seychellarum* and its predator *R. cardinalis* under the three degrees of constant temperatures.

III.2.1.Gross and net reproductive rate (GRR & Ro)

Gross reproductive rate (GRR) is defined as the average total number of female eggs it survives to the last day of reproduction. This parameter does not take the survivorship of the immatures as does net reproductive rate (Ro). So, comparison between both reflects the effect of mortality factor during growth.

GRR values of mealybug were 115.27, 145.27, and 164.33 egg/female, whereas results for net reproductive rate indicated that *I. seychellarum* can replace an average of 89.54, 112.16, and 129.27 daughters after a single generation at 20°, 25° and 30°C, respectively. On the other hand, GRR values of the predator were 136.12, 150.80 and 73.44 egg/female, while Ro values were 120.83, 138.45, and 66.21 daughters after a single generation at 20°, 25°, and 30°C, respectively.

III.2.2. Generation time (Gt.)

The generation time of *I. seychellarum* lasted a shortest period (97.18 days) when insects were reared at 30°C, while they were 216.84, and 101.95 days when the insect was reared at 20°, and 25°C. while these values for the predator at the three tested temperature degrees were 52.68,36.72, and 28.09 days, at 20°, 25°and 30, °C respectively.

III.2.3. Intrinsic rate of increase (rm)

The intrinsic rate of increase (rm) refers to the rate of daily population growth and is considered an important index of potential population performance.

The calculated values of intrinsic rate (rm) showed that these rates for *I. seychellarum* obviously differ at the different tested temperatures being 0.021, 0.046 and 0.050 individuals /day, while for the predator these values were 0.091, 0.134, and 0.149 individual/day at 20°, 25° and 30°C, respectively. It appears that the intrinsic rates of increase for the predator 4.33, 2.91, and 2.98 folds than it for the mealybug at 20, 25 and 30 °C, respectively.

TABLE (VII)

Summary of life table parameters for the prey *I. seychellarum* and its predator *R cardinalis* reared at three constant degrees of temperature.

Temperature °C	Insect specie	Population parameter						rm *R. cardinalsi* / rm *I. seychellarum*
		Gross Reproductive rate GRR	Net Reproductive rate (Ro)	Generation time (days) (Gt.)	Intrinsic rate of increase (rm)	Finite rate of increase (λ)	Population doubling time (Dt)	
20°	*I. seychellarum*	115.27	89.54	216.48	0.021	1.02	33.38	4.33
	R. cardinalis	136.12	120.83	52.68	0.091	1.10	7.62	
25°	*I. seychellarum*	145.57	112.16	101.95	0.046	1.05	14.96	2.91
	R. cardinalis	150.80	138.45	36.72	0.134	1.14	5.16	
30°	*I. seychellarum*	164.33	129.27	97.18	0.050	1.05	13.85	2.98
	R. cardinalis	73.44	66.21	28.09	0.149	1.16	4.64	

III.2.4. Finite rate of increase

The finite rates of increases considered the discrete version of (rm). The calculated values of finite rate of increase of I. seychellarum and R. cardinalis revealed that these rates were greatly affected by different degrees of temperature. These values were 1.02, 1.05, and 1.05 individuals/day/female, while being 1.10, 1.14, and 1.16 individuals/day/female for the predator at 20, 25, and 30 °C, respectively. These results indicated that 25-30 °C seemed to be the most favorable conditions for mass reproduction.

III.2.5. Population doubling time (Dt)

The population of I. seychellarum had the capacity to double every 33.38, 14.96, and 13.85 days. While for the predator they were 7.62, 5.16 and 4.64 days at 20 , 25 and 30 °C, respectively.

IV. Food capacity

The food capacity of the predator on the mealybug throughout larval and adult stages revealed that this capacity not varied from stage to another but also throughout different instars (Table, 8).

Food consumption of the four larval instars and adult stage of the predator on egg stage of the prey were 6.53, 10.93, 18.40, 38.33, and 81.6 eggs/day respectively, with an average 31.16 eggs/day. While the mean number of consumed nymphs of mealybugs were 1.67, 2.80, 5.76, 11.56 and 18.21 individual of nymphs/day, respectively, with an average 8.00 individuals/day. On the other hand, the mean number of consumed adult of mealybugs was 0.80, 1.40, 2.53, 4.87, and 10.27 individuals of mealybug adults/day, respectively with an average 3.97 individual/day.

The total general average number of consumed of different stages of mealybug by only one individual predator of *R. cardinalis* were 14.38 individuals/day.

A view on the analysis of life table parameters it could be concluded that the intrinsic rate of increase (rm) of the prey is lower than of the predator at the three investigated temperatures 20°, 25 and 30 °C, with the proportion of 4.33, 2.91, and 2.98, respectively.

The population of the predator increased with 3.41 as a mean of the three former proportions, more than the population of the mealybug. Therefore, the role of any predator in biological control program, not only depends on its population but also on its food capacity. So, it is necessary to consider the intrinsic rate of increase with food capacity of any predator when estimating the real need of its number for gaining successful control.

TABLE (VIII)

Mean number of preys I. seychellarum consumed by the predator *R. cardinalis* and the population Predatism Power (PPP)

Predator stage	Mean no. of preys *I. seychellarum* consumed by the predator *R. cardinalis*			
	Egg stage	Nymphal stage	Adult stage	Total
First larval instar	6.53	1.67	0.80	9.00
Second larval instar	10.93	2.80	1.40	15.13
Third larval instar	18.40	5.76	2.53	26.69
Fourth larval instar	38.33	11.56	4.87	54.76
Adult stage	81.60	18.21	10.27	110.08
Average	31.16	8.00	3.97	43.13
Mean (rm)	3.41			
Population predatism power (PPP)	106.25	27.28	13.54	
Average (PPP)	49.02			

In the present study, the average consumption rates of the different developmental stages of the predator were 31.16, 8.00, and 3.97 on egg, nymph and adult stages of mealybug respectively with an general average 14.38 individuals/day.

To calculate population predatism power PPP (Table, 8), proportion of rm between the predator and the prey (3.41) multiplied by the food capacity of the predator on the mealybug (31.16, 8.00, and 3.97) resulted in 106.26, 27.28 and 13.54 with an average 49.02, that means that one individuals of the predator *R. cardinalis* can successfully control 49.02 individuals of the mealybug *I. seychellarum.*

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