

Life Table Parameters, Thermal-Requirements and Development Rate of *Stethorus gilvifrons* (Mulsant) Reared on Two-Spotted Spider Mite *Tetranychus urticae* (Koch)

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ABSTRACT

Laboratory experiments were carried out in plant Protection Research Institute during 2016. The effect of temperatures under three different constant temperature (15, 25 and 35 °C) and rate of developmental time immature stages, growth index, development rate, longevity, fecundity, and life table parameters of *Stethorus gilvifrons* (Mulsant), when reared on *Tetranychus urticae* (Koch) were studied. The relationship among developmental rate of each stage and tested temperatures was also investigated. There were significant ranges in total of developmental time immature stages of the predator (male and female) among the three tested temperatures when the predator was reared on *T. urticae* as prey. Mean while, developmental rate of *S. gilvifrons* male were higher at 35°C than 15 and 25°C when reared on this tetranychid mite. Adult male longevity was high significant shorter at 35 than 15 and 25°C. There were significant differences in pre-oviposition period at the three temperatures. In addition, there were significant ranges among pre-oviposition, oviposition, post ovi-position and total longevity when the predator was reared at the three constant temperatures. Fecundity rate was significantly higher at 35°C than at 15°C and 25°C when fed on the *T.urticae* prey. Mean generation time (T) and the doubling time (DT) were higher at 15°C than at 25°C and 35°C when fed on the *T.urticae* individuals. The value of the gross reproductive rate (GRR), net reproduction rate (R_0), intrinsic rate of increase (r_m) and the finite rate of increase (λ) were higher at 35°C than at 15°C and 25°C.

Keywords: *Stethorus gilvifrons* (Mulsant), thermal requirements, biological characteristic, life table, *Tetranychus urticae* (Koch).

INTRODUCTION

Two spotted spider mite *Tetranychus urticae* (Koch).is one of the most polyphagous species of the Tetranychide attacking vegetables and fruit and several agricultural crops causing economic damage (Ripa *et al*, 2006). *T.urticae* is causing to environmental condition and distributed world wide, which causing a loss of the quality and loss yield or the death plants by sucking out the contents of plant scap (Rott *et al* 2000b).Maximum and minimum temperature thresholds and optimal temperature can be estimated for all life table (Roy, *et al*, 2001 and Roy., *et al* 2002). Factors weather such as high and low temperature adversely affected of the population *Stethours spp*, (Kumar, *et al* 2010). They are many of coccinellid such as, *S. gilvifrons* and *S.Punctum* species are the effective natural enemies of the phytophagous mite, included *T.urticae*, *T. piercei*, Gregor, *et al* 1986 and Gencer, *et al* 2005. They are Several studies were attention to the importance of this coccinellid species as the predator. Coccinellid predator could be play a good result for mass rearing and release in open fields and greenhouses, *S. gilvifrons* has a good search activity (Atlihan and Kaydan, 2002; El-Serafi, 2006 and Mohamed *et al.*, 2008).

Life table parameters are helped to know the general biology of an predators and present a valuable picture for the fecundity and growth potential of *S. gilvifrons* 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 species under given conditions (Shih *et al.* 1991). The intrinsic rate of natural increase (r_m) can be used for predator's selection. Moreover, 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) scanty attention has been paid to the rate of developmental time and growth index, longevity, fecundity and life table parameters of this predator to measure these parameters for mass rearing and release. This information to the present study was designed to study certain thermal requirements, biological characters and life table parameters of *S. gilvifrons* at three constant temperatures and reared on *T.urticae*.

MATERIALS AND METHODS

Experiments were conducted at Plant Protection Research Institute, during one year 2016. The predator adults of *Stethous gilvifrons* (Mulsant) were collected from the different fields at Mansoura district. The beetle reared on cowpea bean plants artificially infested with *Tetranychus urticae* (Koch) mentioned for 2-3 week before testing. The eggs laid by females were collected daily, and monitored until hatching. To avoid cannibalism, hatched larvae were reared individually in tubes (10 cm in diameter) in the incubators at 15 ± 0.5 , 25 ± 0.5 and 35 ± 0.5 °C. The relative humidity was $70.0 \pm 5.0\%$ and the photoperiod was 18:6 (L: D) with each temperature. Twenty replicates were carried out for each tested temperature of larval stage of *S. gilvifrons* larvae from the predator were reared on *T. urticae*. Each reared larva was considered a replicates. Feeding on *T.urticae* leaf disc (2.5cm) was artificially infested with fifty of prey individuals. The cell was checked larvae calculated. The predatory larva was transferred to new

fresh number of the same prey. The procedure the experimental cell repeated until the pupation larva of the predators. The stage adult of *S.gilvifrons* feeding on *T.urticae* leaf disc (2.5 cm) was artificially infested by preys individuals. Each newly emerged predators adult was kept separately on the leaf disc in the experimental cells. 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 among female eclosion and initiation of egg laying, 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 post oviposition one as the numbers of days female don't laid the eggs. The longevity of males were recorded. The cells checked daily until the death of the predator dult. 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).

Campbell *et al.* (1974) described the developmental times for eggs, larval instars, total larval stage, pupal stage and total immature stages were used to calculate the developmental rates, which were regressed against temperatures. The regression parameters and slopes were used to showed the lower temperature threshold for development (t_0) and the thermal constant K, as

life table parameters were calculated using a BASIC computer program (Abou-Setta *et al.* 1986) for females reared on *T. urticae*. 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 (L_x), and fecundity (M_x) for each age interval (x) was assessed. The following population growth parameters were determined: the mean generation time (T), gross reproductive rate (GRR) ($=\sum M_x$), the net reproductive increase (R_0), 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.

Degree day requirements have been developed using a variety of non-linear functions that describe the temperature /growth rate relation ship (Wagner *et al.*, 1984), but for most species the linear approximation is acceptable (Taylor and James, 1993).

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 *S. gilvifrons* reared on *T. urticae* 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).

The eggs Incubation period, larval stage were used to calculate developmental rates (1/developmental time) according to Omkar and James(2004), which were regressed against temperature. The regression parameters and slopes were used to estimate the lower temperature threshold for development (T_0) and the thermal constant K, Campbell *et al.*, (1974).

RESULTS AND DISCUSSION

1. Developmental times of immature stages

Statistical analysis of variance (ANOVA) of the experiments indicated that a high significant variations in the incubation periods for immature stages among the three tested temperatures (15, 25, and 35°C) when the predator reared on *T. Urticae* (Table 1).

Data presented in Table (1) showed that the developmental time of the incupation period 7.4,3.6 and 2.2days. The four larval instars developmental time was 6.4, 3.4, 4.6, and 6.2 days, respectively at 15°C, while that was 3.8, 2.6, 2, and 1.8 days at 25 °C, and 2.2, 2, 1.4, and 1.8 days at 35°C, with significant differences in 1st, 2nd, 3rd and 4th instar larvae when reared the predator on *T. urticae* as a prey among the three tested temperatures. The developmental time of larval stage was 20.6, 10, and 7.4 days, with significant differences among the three tested temperatures. The pupal stage averaged 6.4, 5.2, and 2.8 days at 15, 25, and 35°C, with significant differences. The total developmental time of immature stages was 27, 15.2, and 10 days at 15, 25, and 35°C, with significant differences.

Table 1. Developmental times (mean ±SE and on LSD) in days of immature stages of *S. gilvifrons* when reared *T. urticae* at three constant temperatures.

Predator immature	Duration in days			LSD
	15°C	25°C	35°C	
A: Egg incubation period	7.4±0.89a	3.6±0.84 b	2.2±0.45 c	0.712
B: Larval stage:				
1 st instar	6.4±1.14 a	3.8±0.84 b	2.2±0.45 b	1.33
2 nd instar	3.4±0.54 a	2.6±0.55 ab	2±0.71 b	0.912
3 rd instar	4.6±0.54 a	2±0.70 b	1.4±0.55 b	0.834
4 th instar	6.2±1.09 a	1.8±0.84 b	1.8±0.84 b	1.180
Total larval stage	20.6±2.05 a	10±1.24 b	7.4±3.02 c	0.982
C: pupal	6.4±0.55 a	5.2±0.84 b	2.8±0.84 c	1.550
D: Life cycle	27.00±2.24 a	15.3±1.64 b	10±1.87b	3.602

Means followed by the same letter a column for each insect species are insignificantly different at the 5% level probability (Duncan's Multiple Range Test).

2. Longevity and fecundity of adult stage:

Longevity and fecundity of *S. gilvifrons* when reared on *T. urticae* at the three tested temperatures (15,

25, and 35°C presented in Table (2). *T.urticae* as a pre-oviposition , ovipositio, and post oviposition total longevity periods lasted 6, 45.8, 4.6, and 55.2 days, respectively at 15°C, while these periods lasted 2.6, 39.4,5.2 and 46.2 days at 25°C, and 2.2, 35.6, 4.8, and 42.6 days at 35°C.Data presented a significant differences in pre-oviposition period on the three tested temperatures. In addition, there were significant variations among post oviposition, oviposition, and total longevity when the predator were reared at 35°C than at

15°C and 25°C (55.2, 46.6 and 42.6 days) which fed on the same prey. Concerning the fecundity of females eggs, the average number of eggs per female was150.6, 287, and 373.5 at (15, 25 and 35 °C respetively with significant differences among the three tested temperatures (Table 2). Results in Table (2) showed that fecundity rate was significantly higher (17.16) at 25°C than at 15°C & 25°C (3.2 and 6.16) , eggs per day when fed on the same prey.

Table 2. Longevity (mean±SEon L S D) in days of *S. gilvifrons* when reared of *T. urticae* at different temperature.

Temp. (°C)	Sex	Longevity (in days)				Mean total fecundity	Fecundity rate (No. eggs/Female/ day)
		Pre-oviposition	oviposition	Post-Oviposition	Total longevity		
15	♂	-	-	-	61.3±2.28 a	-	-
		6±0.71 a	45.8±4.91 a	4.6±1.3 a	55.2±3.56 a	150.6±2.5a	3.2±0.2 a
25	♂	-	-	-	43.±7.38 b	-	-
		2.6±0.55 b	39.4±2.97 b	5.2±1.92 a	46.6±5.22 a	287±1.8 b	7.3±2.8 b
35	♂	-	-	-	34.3±6.39 c	-	-
		2.2±0.48 b	61±85 b	4.8±2.59 a	42.6±4.15 b	373.5±5.2 c	6.16±0.9 b
LSD	♂	-	-	-	7.39	-	-
		0.97	5.50	3.20	14.287	-	-

Means followed by the same letter a column for each insect species are insignificantly different at the 5% level probability (Duncan's Multiple Range Test).

These result agree with Ahmed and Ahmed (1989)were studied the life history of the predator coccinellid *S. gilvifrons* using *Tetranychus turkestan* (Banks) as prey in laboratory at 20, 25, 30 and 35°C and 65-75% RH. The average incubation period of the eggs was 2.9-5.3 days and the larvae and pupal period was 5.3-12.1 days and 2-5.6 days at 35 and 30°C, respectively. The longest life span for male and female was 167.6 and 124.8 days, respectevily, at 20°C and 47.0 and 42.6 days at 35°C, respectively.Mean while this studied agree with Shih *et al.* (1991) studied in the laboratory at 23.8 ±1.5°C and 70.84 ± 4.3% RH, the coccinellid predator *Stethorus loi* Sasagi it completed the development within 15.27±1.46 days. The durations of the egg, 1st, 2nd, 3rd, and 4th instar larvae and pupal stages were 1.79±0.58, 1.55±0.52, 1.60±0.59, 2.38 ± 0.85 and 3.33±0.76 days, respectively. The pre-ovipositional and ovi-positional of stages were 4.14±1.75 and 28.52±3.67 eggs per day. Females and males lived for 48.38±15.46 and 56.62±18.75 days, respectively. The sex ratio was 1.063 males to one male where as in this study the sex ratioswas 0.45. The intrinsic rate of natural increase was calculated to be 0.160. The mean generation time was calculated to be 24.40 days by Iskander *et al.* (1994) estimated the development of *S. punctillum* in the laboratory on the phytophagous mite, *Tetranychus arabicus* Attiah, with the aim of studying development. Fecundity and feeding capacity of the former species when fed on the latter one at 25±1° and 65±5%RH. The main durations of the egg, larval and pupal stages of *S. punctillum* were 3.67±0.49, 6.67±0.62 and 3.27±0.46 days respectively. The life span was completed in 13.60±0.83 days and longevity of adult female was 64.0±7.42 days. Total number of

eggs/female was 143.93 by daily number of 2.59 eggs. Mirdul *et al.* (2002) in India, studied the life history and feeding potential of *S. gilvifrons* a major predator of the spider mite, *Oligonychus coffeae* (Nietner). The beetle laid eggs singly on both surface of tea leaves and rear or in the middle of a mite colony. There were four instars groups, pupation occurred on both surfaces of the leaves and one end of the pupa was attached to the leaf surface or on the site of pupation. The authors noticed also that the male adults were smaller in body size than female. The predator completed its development in 16.33±1.13 days. The duration of the egg, larval and pupal stages were 4.15±0.94, 8.36±0.48 and 3.82 ± 0.94 days, respectively, was studied in Iran under laboratory conditions at 30-34 deg C and 45-55% RH. A single generation took 14 days to develop from egg to egg. The adult females, of which the life-span averaged 62.4 days, laid an average of 394 eggs each during an oviposition period averaging 59.4 days; the hatching rate was about 98%. Studies on the biology of this coccinellid under lath-house conditions in March-April at 22-26 deg. C and 40-50% RH gave results similar to those obtained in the laboratory. In the field, the number of females produced was double the number of males.Georgis *et al.*(1992). Reported that 34 deg C and 45-55% RH. A single generation took 14 days to develop from egg to egg. The adult females, of which the life-span averaged 62.4 days, laid an average of 394 eggs each during an oviposition period averaging 59.4 days; the hatching rate was about 98%.

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

Growth index of *S. gilvifrons* male was 2.15, 4.25, and 6.07 at the three tested temperatures (15, 25, and 35 °C, respectively) when reared on *T. urticae*

(Table 3). Meanwhile for female, they were 2.20, 5.90, and 7.27 at the three tested temperatures.

Developmental rates of *S. gilvifrons* male and female were 0.022, 0.023, and 0.013 at the three tested temperatures (15, 25, and 35 °C, respectively), when reared on *T. urticae* (Table 3). The female averaged 0.18, 0.023 and 0.023 respectively.

In general, GI and DR were better for *S. gilvifrons* adults (male and female) when reared on *T. urticae* at 35°C than at 15 and 25°C. These results are similar with those Abdel-Salam *et al.* (2010).

Table 3. Growth index of male and female of *S. gilvifrons* reared on *T. urticae* at different temperatures.

Sex	Temp. (°C)	Growth index	Developmental rate
♂	15	2.15	0.022
	25	4.25	0.023
	35	6.07	0.013
♀	15	2.20	0.018
	25	5.90	0.023
	35	7.27	0.023

4. Life table parameters

Results in Table (4) indicated that *S. gilvifrons* females life table parameters when reared on *T. urticae* at the three tested temperatures 15, 25, and 35°C).

Table 4. Life table parameters of *S. gilvifrons* females when reared on *T. urticae* at different temperatures

Temp. (°C)	Life table parameters					
	Mean generation time (T) (in days)	Doubling time (DT) (in days)	Gross reproductive rate (GRR)	Net reproductive rate (R ₀)	Intrinsic rate of increase (r _m)	Finite rate of increase (λ)
15	40.66	0.15	69.48	48.76	9.56	1.1
25	28.76	8.84	122.67	97.52	0.16	1.17
35	20.23	6.15	148.39	105.95	0.23	1.35

5. Degree-Day Requirements

Sharpe and De Michele (1977), studied the relationship between temperature and rate of development in insects and mites is usually calculated as linear, but it is actually curvilinear.

Minimum developmental thresholds (T₀) of egg, larval stages, pupa and life cycle of *S. gilvifrons* immature stages were recorded as 7.4, 4.53, Whereas, *S. gilvifrons* required 410.59 DD to complete their

The mean generation time (T) was 40.66, 28.76, and 20.23 days at 15, 25, and 35°C, respectively when reared on *T. urticae*. The population of this predator could be doubled every 0.15, 8.84, and 6.15 days at 15, 25, and 35°C, respectively when reared on *T. urticae*. The value of gross reproductive rate (GRR) was higher (148.39) at 35 °C than at 15°C and 25 °C (69.48 and 122.67). 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 (R₀), representing the total female births was 105.95 at 35°C. This meant that the population of this predator would be able to multiply 105.95 times when fed on *T. urticae* at the end of each generation. R₀ was 48.76 at 15°C and 97.52 at 25°C. The value of the intrinsic rate of increase (r_m) was 9.56, .16, and 0.23 when the predator was reared on *T. urticae* at the three tested temperatures (15, 25, and 35°C). The finite rate of increase (λ) was 1.1, 1.17, and 1.35 at the three tested temperatures (15, 25 and 35°C) that the population had the capacity to multiply 1.1, 1.17 and 1.35 times per female per day.

development from egg stage to adult when reared on *T. urticae* (Table 5 & Figs. 1). Using the linear model, the estimated low temperature threshold for egg, larva, 1st, 2nd, 3rd, 4th, pupa, and life cycle immature stage of *S. gilvifrons* was 7.6, 4.53, 13.56, 6.78, 0.57 and 7.86 degrees C, respectively while the thermal constant for these stages was 733.10, 695.72, 1059.37, 369.42, 640.62 and 410.59 degree-days, respectively.

Table 5. Linear regression analysis of temperature versus developmental rate, degree-days requirements, and minimum developmental thresholds of *S. gilvifrons* (Muls) female reared on *T. urticae*.

Predator	Stages	Regression	R ²	K(DD)	T ₀
<i>S. gilvifrons</i>	Egg	Y = - 9.591 + 1.825x	0.858	733.10	7.6
	1 st instar	Y = - 8.157 + 1.491x	0.974	695.72	4.53
	2 nd instar	Y = 13.55 + 1.029x	0.995	518.11	13.56
	3 rd instar	Y = - 14.45 + 2.486x	0.993	1059.37	6.27
	4 th instar	Y = 1.576 + 2.486x	0.621	369.42	6.78
	pupa	Y = - 0.0139 + 0.0048x	0.879	640.62	0.57
	Life cycle	Y = - 1.115 + 0.315X	0.997	410.59	7.86

The present findings were similar to the data by Taghizadeh, *et al.* (2008) who found the total development time at temperatures tested was 56.47, 31.19, 18.53, 17.54, 12.49, and 9.27 days, respectively, which recorded a significant decrease of development

time with increasing temperature. under laboratory conditions at 15, 20, 25, 28, 30, 35 and 40 degrees C and recorded no development occurred at 40 degrees C.

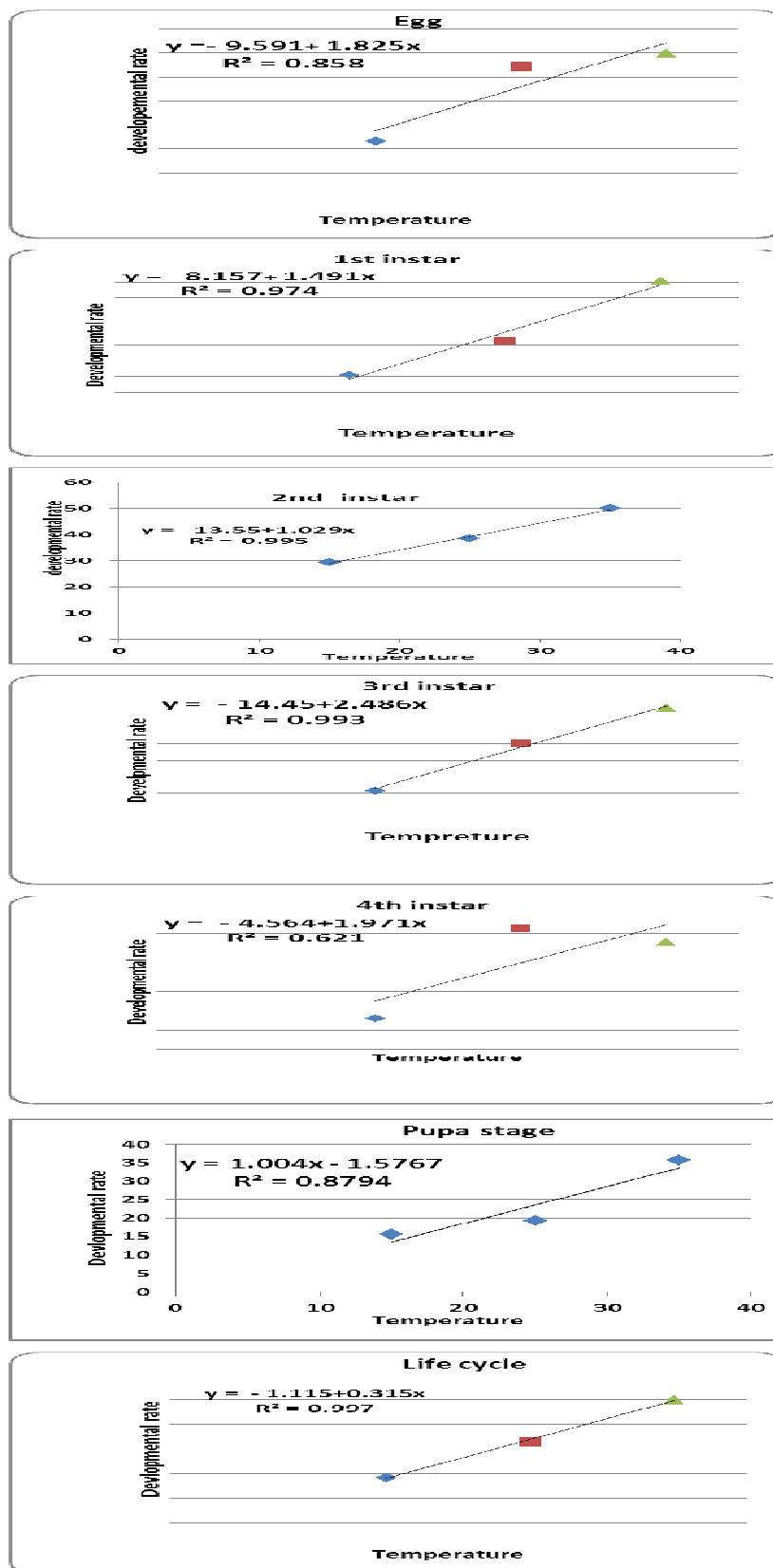


Figure 1. Linear regression analysis of temperature versus developmental rate, degree - days requirements, and minimum developmental thresholds of *S.gilvifrons* (Mulsant) immature stage reared on *T. urticae* (Koch)

Peterson *et al.* (1994) in New Zealand, recorded the development of the coccinellid *Stethorus bifidus* Kapur at 65.80% RH, LD 6.8 and 8.5, 12.5, 17.0, 21.0, 24.5 and 27.5°C using *Tetranychus lintearius* (Dufour) as a prey they found that the relationship between temperature and development rate was linear between 12.5 and 27.5°C for eggs, 4th larval instars and pupae development thresholds ranged from 9.4°C for 3rd instar larvae to 11.9°C for eggs, development from egg to adult lasted 217 days.

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 and a high reproductive capacity.

In conclusion, *S. gilvifrons* 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 monitored and manipulated in an integrated pest management (IPM). This information may be used as an important mean in planning successful integrated pest management (IPM) program for this spider mite.

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جداول الحياه و الإحتياجات الحرارية و معدلات النمو للمفترس عند *Stethorus gilvifrons* (Mulsant) تغذيته على العنكبوت الأحمر ذو البقعتين *Tetranychus urticae* (Koch) فاطمه محمد صالح

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أجريت هذه الدراسة العملية في معهد بحوث وقاية النباتات فرع المنصورة خلال عام ٢٠١٦. وذلك لدراسة تأثير ثلاث درجات ثابتة من الحرارة و هي ١٥ و ٢٥ و ٣٥ درجة مئوية على المعدلات و الوقت اللازم للنمو للأطوار الغير كاملة و معدل الخصوبة و فتره الحياه للأطوار الكامله للمفترس *Stethorus gilvifrons* (Mulsant) و ذلك عند تغذيتها على العنكبوت الأحمر ذو البقعتين *Tetranychus urticae* Koch و كذلك تم دراسة العلاقة بين معدلات النمو لكل طور من أطوار المفترس. و تبين وجود ارتباط معنوي بين الوقت اللازم لنمو الأطوار الغير كاملة لكل من الإناث و الذكور للمفترس بينما وجد ان معدلات النمو للذكور الكاملة كانت أعلى على درجة ٣٥ درجة مئوية عنها عند التربيه على ١٥ و ٢٥ درجه مئوية. و كذلك أظهرت الإناث الكامله ارتباط معنوي بين فترات ما قبل وضع البيض و فتره وضع البيض و ما بعد وضع البيض ودرجات الحرارة. أما عن الكفاءة التناسليه فكانت أعلى على درجة ٣٥ عن ١٥ و ٢٥ درجة مئوية. وجد أن متوسط فتره الجيل و الزمن اللازم للتضاعف كانت أكبر عند التربيه على درجة حراره ١٥ بالمقارنة بدرجتى ٢٥ و ٣٥ درجة مئوية. و كذلك معدل التضاعف و قيم معامل التضاعف و معدل التكاثر و معدل الزيادة النهائي كانت أعلى عند درجه ٣٥ درجة مئوية عن ٢٥ و ١٥ درجة مئوية عند التربيه على العنكبوت الأحمر ذو البقعتين.