ACARINES, 14:37-44. 2020

Thermal requirements and life table parameters of the predatory mite, *Neoseiulus californicus* (McGregor) fed on *Tetranychus urticae* Koch (Acari: Phytoseiidae: Tetranychidae)

Rania A. El-Nahas[1], Ahmad H. Fouly[2], Abd EL- Twab A. yousef[2] & Abdin M. Khalil[1]

[1]*Cotton and Field Crops Acarology Department, Plant Protection Research Institute, A.R.C., E-mail, rania.elnahas1@gmail.com*

[2]*Agriculural Zoology. Department Faculty of Agriculture Mansoura Univesity, Egypt. E-mail, ahfouly253@yahoo.com*

ABSTRACT

The predatory mite, *Neoseiulus californicus* (McGregor) (Acari: Phytoseiidae) is an important biological control agent of the two-spotted spider mite, *Tetranychus urticae* Koch (Acari: Tetranychidae) infesting many crops worldwide. Biology, life table parameters and thermal requirements of *N. californicus* were evaluated in laboratory at 20, 27, 30±2ºC and 70±5% RH. Spider mite, *T. urticae* is an important pest of soybean crop in Egypt. The duration of the immature stages of *N. californicus* ranged from 4.22 to 7.35 days for female and from 3.80 to 7.10 days for male when they were kept at 20 and 30°C, respectively. The mean generation time (TG) decreased with increasing temperature from 19.48 days to 12.93 days at 20 to 30°C, respectively. The intrinsic rate of increase (r_m) and finite rate of increase (λ) were highest at 27 and 30 ºC. The highest total consumption rate of prey was 223.4 individuals when adult female fed on *T. urticae* motile stages at 30 ºC, while the lowest rate was 162.60 individuals at 20 ºC during the whole life span. Minimum developmental thresholds (t_0) of egg, larva, protonymph, deutonymph and total immature stages of *N. californicus* female averaged 13.20, 12.75, 3.29, 0.0 and 6.66 ºC, respectively. The predatory female of *N. californicus* required 500 DDUs to reach adulthood. Therefore, a thermal range of 27°C was the most suitable condition to rear the target predatory mite.

Keywords: Phytoseiidae, spider mite, biological aspects, life table, consumption, temperature.

INTRODUCTION

Leguminous plants (Fabaceae) are considered of a great economic importance for local consumption and exportation in Egypt. Legumes play a vital role in agro-ecosystems based on their ability to form a symbiosis with soil rhizobia that fix atmospheric nitrogen. Soybean, *Glycine max* (L.), is considered as a good source of oil and protein for human and livestock consumption. The two- spotted spider mite, *Tetranychus urticae* Koch (Acari: Tetranychidae) has a wide range of host plants including field crops, greenhouse crops, ornamentals and fruit trees. However, the spider mite does not accept all plants to the same degree because of differences in nutritive and toxic constituents (Sawires, 1985; Migeon et al. 2011; Rinehold et al. 2015).

Phytoseiid mites are the most important natural enemies of mite pest. The predatory mite, *Neoseiulus californicus* (McGregor) (Acari: Phytoseiidae) is widespread all over the world and considered as one of the most promising species for biological control of spider mites (Castagnoli and Simoni 2004). It was classified according to their lifestyle and type of predation as a generalist predator feeding on many mite species as well as pollen (McMurtry and Croft 1997). It is also one of the major phytoseiid predators of spider mites and is associated successfully with their dense webbing as it can cut through with its chelicerae (McMurtry et al. 2013).

Several researchers examined the effect of prey type, temperature and plant species on development and reproduction of *N. californicus* (El-Laithy and El-Sawi 1998; Gotoh et al. 2006; Ali and El-Liathy 2005; Kuştutan and Çakmak 2009; Toldi et al. 2013; Elhalawany et al. 2017; Gonçalves et al. 2019; Kaur and Zalom 2019).

The aim of this study was to evaluate the effect of temperatures on the development, food consumption and life table parameters of *N. californicus* using *T. urticae* motile stages as a prey. Also, thermal requirements of *N. californicus* for development were estimated.

MATERIALS AND METHODS

T. urticae source:

The two-spotted spider mite, *T. urticae* was collected from naturally infested soya and green beans from Dakahlia Governorate then maintained in the laboratory on clean freshly *Hibiscus rosasinensis* L plant leaves.

Rearing of *T. urticae*.

Petri dishes (12 cm in diameter) were used as platforms for observing the mites in the laboratory. Disks of *H. rosasinensis* leaves were arised upside down on moisten cotton pad (10 cm in diameter and 1cm thick) soaked with water. All ends of leaf discs were covered with fine wet cotton walls to prevent the mite individuals from escaping. Leaf discs were examined every three days and replaced with fresh ones when over-crowding of mites.

Stock culture of *Neoseiulus californicus*

A stock culture of *N. californicus* was started with a gravid female, which collected from leaves of Soybean at Dakahlia Governorate. The predatory mite was reared on a freshly hibiscus leaves placed upside down on moisten cotton pad in plastic tray. Water was added as needed to maintain suitable moisture.

A surplus amount of *T. urticae* motile stages individuals were offered daily to the predator as a main source of food and maintained at three degrees of temperatures 20, 27, 30±2ºC and 70±5% RH. Newly deposited eggs of the predator were transferred singly to experimental units, each of which consisted of a leaf disk (2 cm diameter), manufactured from hibiscus leaves floating on water soaked cotton bed (10 cm diameter and 1cm thick) and placed lower side up on a Petri dish (15 cm in diameter). The borders of the leaves were surrounded by Tangle-foot (a mixture of Canada balsam and castor & citronella oils) to confine the mite and prevent it from escaping. A known number of prey immature stages captured from the culture were offered to the predator newly hatched larvae as a food. Twenty replicates for male and female were used for each temperature 20, 27 and 30±2°C. Each replicate was observed daily to record the number of eggs laid and the number of prey immature stages consumed by the female during its life span until died. Every two days the leaf disc with motile stages of *T. urticae* in each arena was replaced with new ones.

Statistical analysis

Thermal requirements for different developmental stages of *N. californicus* were calculated using Microsoft Excel application for developmental rates (1/developmental times). Using linear regression equation (Y= a ± b X). Developmental threshold (t_0ºC) and thermal degree days (K value) (physiological time) were calculated.

Observations of different biological aspects were recorded daily. Data were statistically analyzed by ANOVA-test to determine the significant differences between means (LSD-test, where P>0.05) using SAS statistical software (SAS Institute, 2003). Life table parameters of *N. californicus* were calculated using software developed by Abou-Setta et al. (1986) according to Birch (1948).

RESULTS AND DISCUSSION

Development periods of *Neoseiulus californicus*.

The biology experiment was constructed at performed to qualify the effect of the temperatures 20, 27, 30±2 ºC and 70±5% RH on the progress time of the predatory mite *N. californicus* when motile stages of *T. urticae* were supplied as food source.

Results in Table (1) showed that the duration of the predatory individuals was accelerated with raising temperature, whereas the egg incubation time averaged 3.20, 1.75 and 1.30 days for *N. californicus* female. Itt was 3.0, 1.65 and 1.25 days for male when kept at 20, 27 and 30ºC, respectively (Table 2). The larva, protonymph and deutonymph were longest at 20°C as 2.25, 2.20 and 2.9 days for female, and 2.35, 2.15 and 2.60 days for male, respectively. The shortest values of development were observed at 30°C as 0.95, 1.37 and 1.9 days for female, and 0.90, 1.25 and 1.65 days for male, respectively (Tables 1 and 2). Therefore, it was noticed that the total developmental time was longest at 20°C and shortest at 30°C. The life cycle lasted 10.55, 7.05 and 5.52, days for female at the same above conditions , while the male followed the same pattern but shorter than female, respectively (Tables1 and 2).

Longevity and fecundity of *N. californicus*

The pre-oviposition, oviposition and post oviposition periods were decreased as temperature increased from 20 to 30°C (Table 1). Longevity was 32.35 and 25.20 days for female and male kept at 20°C, respectively. The shortest periods were 18.6 and 15.5days for mites kept at 30°C. The life span lasted 42.90, 30.20 and 24.12days for female and 35.30, 23.25 and 20.55days for male of *N. californicus* incubated at 20, 27 and 30°C, respectively (Tables 1 and 2). Mean total and daily fecundity of *N. californicus* were highest when mites were incubated at 27°C. The fecundity recorded 33.90, 42.60 and 31.90 eggs/female at 20, 27 and 30°C, with a daily rate of 1.29, 2.21 and 2.08 eggs/female/day at 30, 27 and 20°C, respectively (Table 1). These values were lower than that of Gotoh et al. (2004) and Escudero and Ferragut (2005), whom reported 41.6 and 57.78 eggs/female, respectively.

Table 1. Mean duration (days) of incubation, development time and longevity of *Neoseiulus californicus* female fed on *T. urticae* kept at 20, 27 and 30 ±2ºC and 70±5% RH.

Biological aspects	Mean duration ±SD of female stages		
	20 ºC	27 ºC	30 ºC
Egg	3.20 ± 0.26	1.75 ± 0.42	1.30 ± 0.26
Larva	2.25 ± 0.49	1.30 ± 0.35	0.95 ±0.28
Protonymph	2.20 ± 0.59	1.60 ± 0.39	1.37 ± 0.26
Deutonymph	2.90 ± 0.57	2.40 ± 0.57	1.90 ± 0.52
Immature	7.35 ± 1.25	5.30 ± 0.79	4.22 ± 0.71
life cycle	10.55 ± 1.32	7.05 ± 0.86	5.52 ± 0.82
Generation	13.20 ± 1.34	8.50 ± 1.05	6.82 ± 0.98
Preoviposition	2.65 ± 0.47	1.45 ± 0.37	1.30 ± 0.26
Oviposition	26.50 ± 2.17	19.30 ± 1.64	15.40 ± 1.51
Postoviposition	3.20 ± 0.54	2.40 ± 0.74	1.90 ± 0.39
Longevity	32.35 ± 2.53	23.15 ± 1.60	18.60 ± 1.60
Fecundity	33.90 ± 4.33	42.60 ± 5.04	31.90 ± 3.31
Daily rate	1.29 ± 0.19	2.21 ± 0.20	2.08 ± 0.24
Life span	42.90 ± 2.92	30.20 ± 2.06	24.12 ± 2.20

Table 2. Mean duration (days) of incubation, development times and longevity of *Neoseiulus californicus* male fed on *T. urticae* kept at 20, 27 and 30 ±2ºC and 70±5% RH.

Biological aspects	Mean duration ±SD of female stages		
	20 ºC	27 ºC	30 ºC
Egg	3.00 ± 0.24	1.65 ± 0.34	1.25 ± 0.26
Larva	2.35 ± 0.47	1.10 ± 0.21	0.90 ± 0.32
Protonymph	2.15 ± 0.53	1.60 ± 0.39	1.25 ± 0.26
Deutonymph	2.60 ± 0.39	2.30 ± 0.48	1.65 ± 0.58
Immature	7.10 ± 0.88	5.00 ± 0.41	3.80 ± 0.67
life cycle	10.10 ± 0.88	6.65 ± 0.41	5.05 ± 0.60
Longevity	25.20 ± 2.86	16.60 ± 2.12	15.50 ± 1.58
Life span	35.30 ± 2.63	23.25 ± 2.43	20.55 ± 1.64

A lower fecundity as 30.7 and 35.2eggs/female at 24 and 30°C, respectively for *N. californicus* observed by Lebdi-Grissa et al. (2005).In addition, the biological characteristics of *N. californicus* from cultivated strawberry plants and noticed that the average length of egg-adult was longer for females (5.69) than for males (5.35) Toldi et al. (2013). Moreover, found that *N. californicus* completed its developmental on different prey types with a life cycle of 7.02 to 10.25 days Elhalawany et al. (2017). They added that the longest female longevity and highest fecundity one was recorded when this mite fed on *T. urticae* motile stages (49.3 eggs/female), whereas lowest fecundity (12.6 eggs/female) was recorded feeding on motile stages of *Tegolophus guavae*.

Thermal requirements:

Results of applying the linear model to the relation between temperature and the rate of development in mite's data as shown in (Table 3) indicated that, R^2 values of *N. californicus* ranged between 0.74and1.0 of egg, larva, protonymph, deutonymph, and immature stages for female and male. Using the equation resulted in determination of the lower thresholds (t_0) as13.20& 12.9, 12.75& 13.9, 3.29&5.84, 0.0 &1.31, 6.66& 8.6, 9.03°C for egg, larva, protonymph, deutonymph and immature stages for female and male, respectively. Consequently, the thermal constant (K) was 22.72&, 22.2, 17.24& 14.7, 37.03& 32.25, 62.5& 52.6, 111.1& 90.9 DDs for the two previous stages, respectively as physiological times required for this species phenomena.

Similar results were obtained by Kuştutan and Çakmak (2009) who found that the theoretical development threshold for egg was 8.9°C, and 25.6 DD were required for hatching. The shortest post-embryonic period (larva, protonymph, and deutonymph stages) was achieved when *N. californicus* was kept at 25 and 30°C, and it was longer at 15°C. They also found that the total development period (egg to adult) decreased linearly with increasing temperature (R^2 = 0.950). The total developmental threshold obtained with regression analysis was estimated to be 7.8°C. *N. californicus* required 83.3 DD to complete its development from egg to adult.

Life table parameters

The life table parameters of *N. californicus* obtained from female age-specific life tables is shown in Table (4). The mean generation time (T) and doubling time (DT) values decreased with temperature increase, thus the reproduction of mite increase at 30, 27°C than at 20°C. R_o was maximum at 27°C.

The obtained intrinsic rate of increase r_m value was higher when mites were incubated at 30°C (0.238 individuals/female/day) than that obtained at 27 and 20°C. The corresponding finite rate of increase e^{rm} (λ) was 1.15, 1.26 and 1.26 when *N. californicus* kept at 20, 27 and 30°C, respectively. The net reproductive rate R_0 of *N. californicus* increased from 12.93 and 16.41 times individual per generation when mites kept at 30 and 20°C to 23.74 individuals per generation at 27°C (Table 4).

The survival rate was 70, 80 and 70% for mites kept at 20, 27 and 30°C, respectively. The sex ratio of females per total offspring was 0.7, 0.8 and 0.70 at 20, 27 and 30˚C, respectively. Gross reproduction rate (GRR) recorded the highest value averaged 31.97 while the lowest was 19.67 eggs/generation when *N. californicus* was incubated at 27 and 30°C, respectively. The population of this predatory mite is reduced by half (50% mortality) from 35.0 days at 20°C to only 20.0 days at 30°C.

These results are in accordance with those of Ali and El-liathy (2005) who indicated that the highest value of the intrinsic rate of natural increase (r_m) 0.24 of *N. californicus* was obtained when it fed on *T. urticae* immature stages, while the lowest value (0.13) was noticed when mites fed on eggs of *T. urticae* or adult of *T. cucurbitacearum*. In addition, the net reproduction rate (R_o) of *N. californicus* was highest at 25ºC (22.92 ♀♀/generation) and lowest at 30ºC (16.74♀♀/generation). Kuştutan and Çakmak (2009) also found that the mean total and daily fecundity of *N. californicus* (species) were highest at 25°C, and were statistically different with those obtained at 20 and 30°C. The net reproductive rate (R_0) was highest at 25°C (42.92 ♀♀/ generation). The longest mean generation period (T_0) occurred at 20°C (12.96 days) and the shortest occurred at 30°C (10.12 days).

Table 3. Linear regression analysis values for the effect of temperature on *Neoseiulus californicus* developmental rates.

Stage	Sex	a	b	t_0	K	R^2
Egg	Female	-0.581	0.044	13.20	22.72	0.97
	Male	-0.581	0.45	12.9	22.2	0.98
Larva	Female	-0.74	0.056	12.75	17.24	0.96
	Male	-0.94	0.068	13.9	14.70	1.0
Protonymph	Female	-0.89	0.027	3.29	37.03	0.99
	Male	-0.181	0.01	5.84	32.25	0.94
Deutonymph	Female	0.0	0.016	0.0	62.5	0.88
	Male	-0.025	0.019	1.31	52.6	0.74
Immature	Female	-0.060	0.009	6.66	111.1	0.95
	Male	-0.045	0.011	8.6	90.90	0.94
Life cycle	Female	-0.073	0.008	9.03	125	0.96
	Male	-0.93	0.009	10.33	11.11	0.95
Longevity	Female	-0.013	0.002	6.5	500	0.96
	Male	-0.011	0.002	5.5	500	0.98
Life span	Female	-0.012	0.001	12.0	1000	0.96
	Male	-0.012	0.002	6.0	500	0.99

a = Intercept, b= slope of temperature, t_0= (-a/b), K= DDUs (1/b)

The highest intrinsic rate of increase (r_m) for *N. californicus* was observed at 25°C (0.337 ♀/ ♀/day) and the lowest was at 20°C (0.2467 ♀/♀/day). **Maroufpoor et al. (2013)** investigated the life tables of *N. californicus* feeding on *Panonychus ulmi* (Koch) at 20 and 25°C. He found that the duration of immature stages varied from 7.52 to 5.12 days, at 20 and 25°C, respectively. He also noticed that he net reproductive rate (R_0) increased with increasing temperature from 20.84 female offspring to 31.46 female offspring when it kept at 20–25°C, respectively. The obtained values of the intrinsic rate of increase (r_m) were highest at 25°C (0.237 day $^{-1}$). The mean generation time (*T*) decreased with increasing temperature from 18.86 days to 14.45 days at 20–25°C, respectively. In conclusion, he showed that *N. californicus* would be able to develop at temperature range of 20–25°C feeding on *P. ulmi* and has the suitable potential to control it. Toldi et al. (2013) noticed that the average length of egg-adult of *N. californicus* was higher for females (5.69±0.08) than for males (5.35±0.11). They added that the sex ratio was 0.66 and the innate capacity for increase (r_m) was 0.15 ♀/♀/ day. The net reproductive rate (R_o) was 17.10 times/generation, with an average to each generation (T) of 19.35 days. Moreover, they showed that a greater oviposition was observed on the 11st day after its onset, with 2.7 eggs/ female/day and the average was 38.14±5.58 eggs/female. The net increase rate (λ) was 1.41 female/ day. *N. californicus* showed to reproduce properly when feeding on *T. urticae*. Elhalawany et al. (2017) found the net reproduction rate of increase (R_o), intrinsic rate of natural increase (r_m) and finite rate of increase (λ) were highest feeding on *T. urticae* motile stages as 35.59, 0.272 and 1.31, respectively. Gonçalves et al. (2019) evaluated the biological features of *N. californicus* feeding on *Schizotetranychus oryzae* on leaves of flooded rice. They also noticed that intrinsic rate of increase (r_m) of the predator feeding on *S. oryzae* was 0.21♀/♀/day. Therefore, they stated that *S. oryzae* considered a suitable prey for *N. californicus* under laboratory conditions. Kaur and Zalom (2019**)** indicated that *N.californicus* preferred to consume *Eotetranychus lewisi* and cause more reduction % (90.0–96.66) compared to *T. urticae* (60.0–80.0).

Table 4. Thermal effect on life-table parameters of *Neoseiulus californicus*.

Parameter	20 ºC	27 ºC	30 ºC
Mean generation time (T_G)[a]	19.48	13.45	12.93
Gross reproduction rate (GRR)[b]	26.37	31.97	19.67
Survival rate %	70	80	70
50% mortality	35.0	26.0	20.0
Sex ratio (females/total)	0.7	0.8	0.70
Net reproductive rate (R_o)[b]	16.41	23.74	12.93
Intrinsic rate of increase (r_m)[c]	0.143	0.235	0.238
Finite rate of increase (λ)	1.15	1.26	1.26
Doubling generation (DT)[a]	4.84	2.94	2.91

[a] Day, [b] per generation, [c] individuals/female/day.

The age specific survivorship (l_x) and age-specific fecundity (m_x) curves for *N. californicus* was illustrated in Figure (1). The daily age-specific survival rate was highest at 27ºC and decreased at 30 and 20 ºC. The maximum number of eggs produced at 27ºC (day 12: 2.24 eggs/♀/day) while, these value at 30°C was (day 10: 1.96 eggs/♀/day) and the lowest value was (day 16: 1.33 eggs/♀/day) at 20 ºC. After that, egg production decreased gradually. The highest survival rate of females was 0.8% at 27°C, while lowest value was 0.70% at 30 and 20°C.These results are in accordance with that of Kuştutan and Çakmak (2009) found the post-oviposition period of *N. californicus* was significantly longer and its longevity significantly greater at 20°C than at higher temperatures. Mean total and daily fecundity were highest at 25°C, which were significantly different from those obtained at 20 and 30°C. Elhalawany et al. (2017) indicated that the feeding predator on motile stages of *T. urticae* is better for long-term preservation of *N. californicus* females than other preys due to a shorter developmental duration, a higher egg production and more favorable life table values. However, further field studies are needed to prove the ability of *N. californicus* to control *T. urticae* and there's a lack of studies to determine the quantities of predators required to keep populations of *T. urticae* below the economic threshold level.

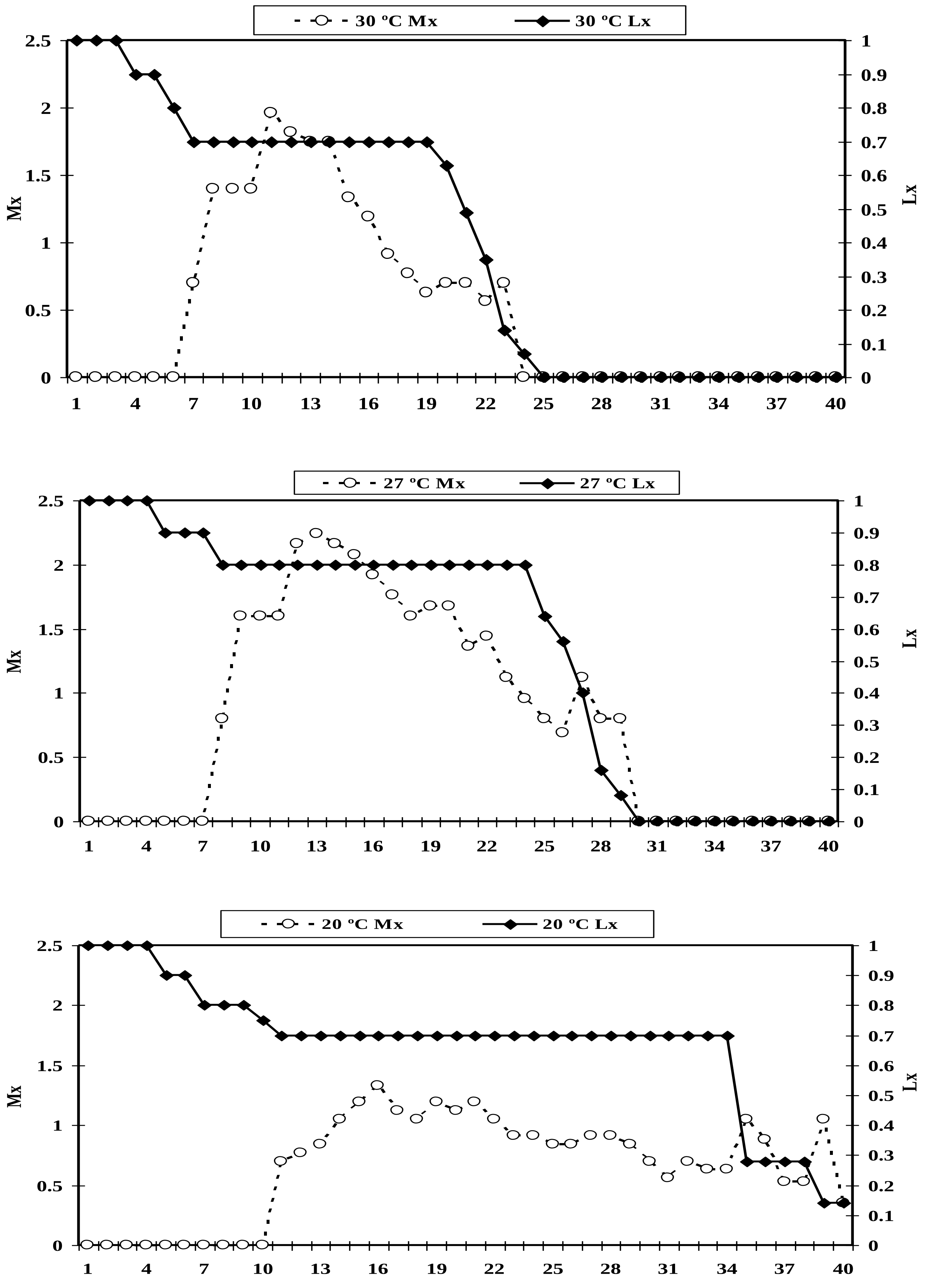

Figure 1. the age specific survivorship (l_x) and age-specific fecundity (m_x) curves for *Neoseiulus californicus* at 20, 27 and 30 ºC.

Food consumption:

Food consumption of the predaceous mite, *N. californicus* when fed on *T. urticae* motile stages is presented in Tables (5 and 6). Larva of both sexes of *N. californicus* successfully feed on the motile stages of *T. urticae* whereas it sucked an average of 1.80, 1.60 and 1.40 prey for female while, for male it prey on 1.60, 1.40 and 1.20 individuals, respectively. Immature stages of female consumed 10.50, 8.80 and 8.10 ind., while, immature stages of male consumed 9.30, 8.20 and 7.10 indi. at 30, 27 and 20ºC, respectively with significant differences (P< 0.0003).

The female during pre-oviposition period devoured (19.50, 12.50 & 10.10) with significant differences (P< 0.0001); while, during the oviposition period devoured (167.30, 158.30 and 131 ind.) and during the post-oviposition period was consumed (26.10, 19.16 and 13.10) at 30, 27 and 20ºC, respectively with significant differences (P< 0.0001). When *T. urticae* individuals dealt with the predatory mite, *N. californicus*, the female consumed 223, 198.70 and 162.60 individual during life span. Whereas, the male consumed 165.60, 153.10 and 111.40 motile stages at 30, 27 and 20ºC, respectively (Table 20 and Figs. 21 and 22).

The obtained results are nearly similar to El-Laithy and El-Sawi (1998) who evaluated predation rate of *Neoseiulus californicus* on *Tetranychus urticae* and *Eriophyes dioscoridis*. The highest rate of prey consumption was observed during the oviposition period regardless of diet source. Greco et al. (2005) observed that the predator *N.californicus* (McGregor) was effective for controlling *T. urticae* under laboratory conditions. Lebdi-Grissa et al. (2005) also showed a significant difference between the developmental phases of egg-adult for females and males of *N.californicus*, being lower for males at the temperatures of 24, 30, and 35°C. Gotoh et al. (2006) found that the immature females had a higher predation rate than immature males. Pre-oviposition period, oviposition period and the number of eggs laid per female were not significantly affected by either the plants or the type of prey eggs. Elhalawany et al. (2017) indicated that the highest consumption rate of adult female was 496.2 individuals when fed on *T. guavae*; while the lowest was 161.2 individuals on *T. urticae* motile stages.

Table 5. Mean number (± SD) of prey consumed by *Neoseiulus californicus* female reared on different temperatures.

Developmental stages	30 ºC	27 ºC	20 ºC	F-value	P- value	L.S.D at $_{0.05}$
Larva	1.80±0.63 a	1.60±0.52 a	1.40±0.52 a	1.29	0.292	0.51
Protonymph	4.30±0.67 a	3.70±0.67 ab	3.50±0.71 b	3.69	0.038	0.62
Deutonymph	4.40±0.97 a	3.50±0.71 b	3.20±0.42 b	7.26	0.0003	0.67
Immature	10.50±0.97 a	8.80±1.40 b	8.10±1.10 b	11.12	0.0003	1.07
Preoviposition	19.50±4.38 a	12.50±4.38 b	10.10±2.96 b	15.19	0.0001	3.63
Oviposition	167.30±26.0 a	158.30±26.2 a	131.30±26.1 b	5.14	0.0128	23.97
Postoviposition	26.10±4.61 a	19.10±4.61 b	13.10±4.61c	19.96	0.0001	4.22
Adult longevity	212.90±33.1 a	189.90±33.1 a	154.50±31.6 b	8.13	0.0017	29.94
Life span	223.40±33.3 a	198.70±33.0 a	162.60±32.0 b	8.69	0.0001	30.1

Means within rows followed by the same letter were not significantly different at the 5%**.**

Table 6. Number of prey *T. urticae* consumed of (Mean ± S.D.) *Neoseiulus californicus* male at 20, 27 and 30 ±2ºC and70±5% RH.

Developmental stages	30 ºC	27 ºC	20 ºC	F-value	P- value	L.S.D at $_{0.05}$
Larva	1.60±0.52 a	1.40±0.52 a	1.20±0.42 a	1.69	0.203	0.44
Protonymph	3.90±0.74 a	3.30±0.67 ab	2.90±0.57 b	5.75	0.008	0.60
Deutonymph	3.80±0.76 a	3.50±0.71 ab	3.00±0.47 b	3.64	0.039	0.61
Immature	9.30±1.25 a	8.20±1.14 b	7.10±0.88 c	10.02	0.0006	1.0
Adult longevity	156.30±26.1 a	145.50±17.9 a	100.90±25.7 b	15.55	0.0001	21.61
Life span	165.60±26.0a	153.10±19.0 a	111.40±26.56 b	13.78	0.0001	22.2

Means within rows followed by the same letter were not significantly different at the 5%**.**

REFERENCES

Abou-Setta MM, Sorrell RW, Childers CC. 1986. Life 48: a BASIC computer program to calculate life table parameters of an insect or mite species. *Floarida Entomology*, 69: 690–697.

Ali FS, El-Liathy AY. 2005. Biology of the predatory mites *Neosiulus californicus* (McG) and *Phytoseiulus persimilis* A.-H. (Acari; Phytoseiidae) fed on *Tetranychus urticae* Koch and Tetranychus *cucurbitacearum* (Sayed). *Egyptian Journal of Biological Pest Control*, 1 (2): 85–88.

Birch LC. 1948. The intrinsic rate of natural increase of an insect population. *Journal Animal Ecolology*, 17:15–26.

Castagnoli M, Simoni S. 2004. *Neoseiulus californicus* (McGregor) (Acari Phytoseiidae) survey of biological and behavioral traits of a versatile predator. *Redia,* 85: 153–164.

Elhalawany AS, Abd El-Wahed NM, Ahmed F. 2017. Influence of prey type on the biology and life table parameters of *Neoseiulus californicus* (McGregor) (Acari: Phytoeiidae). *Acarines*, 11:15–20.

El-Laithy AYM., El-Sawi SA 1998. Biology and life table parameters of the predatory mite *Neoseiulus californicus* fed o different diets. *Zeitschift fur Pflanzekankheiten und Pflanzenschutz*, 105 (5): 532–537.

Escudero LA, Ferragut F. 2005. Life-history of predatory mites *Neoseiulus californicus* and *Phytoseiulus persimilis* (Acari: phytoseiidae) on four spider mite species as prey, with special reference to *Tetranychus evansi* (Acari: Tetranychidae). *Biological control*, 32: 378 – 384.

Gonçalves D, Cunha dues, Rode PDE, Toldi M, Ferla NJ. 2019. Biological features of *Neoseiulus californicus* (Acari: Phytoseiidae) feeding on *Schizotetranychus oryzae* (Acari: Tetranychidae) kept on rice leaves. *Journal of Economic Entomology*, 112 (5): 2103–2108.

Gotoh T, Yamaguchi K, Mor K. 2004. Effect of temperature on life history of the predatory mite *Amblyseius* (*Neoseiulus*) *californicus* (Acari: Phytoseiidae). *Experimental and Applied Acarology*, 32: 15–30.

Kaur P, Zalom FG. 2019. Consumption rate and predatory preference of the predaceous mite, *Neoseiulus californicus* to *Tetranychus urticae* and *Eotetranychus lewisi* on strawberry in California, USA., *Current Research*, 116(12): 2097 –2101.

Kuştutan O, Çakmak I. 2009. Development, fecundity, and prey consumption of *Neoseiulus californicus* (McGregor) fed *Tetranychus cinnabarinus* Boisduval. *Turkish Journal of Agriculture and Forestry*, 33(1): 19 –28.

Lebdi-Grissa K, Vaninpe G, Lebrun P. 2005. Parametres biologiques et demographiques de *Neoseiulus californicus* (Acari: Phytoseiidae) a differentes températures. *Acarologia,* 45 (1): 13 –22.

Maroufpoor M, Ghoosta Y, Pourmirza AA. 2013. Life table parameters of *Neoseiulus californicus* (Acari: Phytoseiidae), on the European red mite, *Panonychus ulmi* (Acari: Tetranychidae) in laboratory condition. *Persian Journal of Acarology*, 2(2): 265–276.

McMurtry, J.A., B.A.Croft, 1997. Life-styles of phytoseiid mites and their roles in biological control. *Annual Review of Entomology*, 42, 291-321.

McMurtry JA, Moraes GJDe, Sourassou NF. 2013. Revision of the lifestyles of phytoseiid mites (Acari: Phytoseiidae) and implications for biological control strategies. *Systematic and Applied Acarology*, 18 (4): 297–320.

Migeon A, Nouguier E, Dorkeld F. 2011. Spider mites web: a comprehensive database for the Tetranychidae. *Trends in Acarology*, 557–560

SAS Institute. 2003. SAS Statistics and graphics guide, release 9.1. SAS Institute, Cary, North.

Sawires ZR. 1985. The effect of mite infestation on the components of soybean plants. *Ph.D. Thesis*, *Faculty Agriculture Cairo University*, 206 pp.

Toldi M, Ferla NJ, Dameda C, Majolo F. 2013. Biology of *Neoseiulus californicus* feeding on two-spotted spider mite. *Revista Biotemas*, 26 (2): 105 –111.