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LIFE TABLE PARAMETERS OF *PHYTOSEIUS PLUMIFER* (CANESTRINI & FANZAGO) REARED AT DIFFERENT TEMPERATURES (ACARI: PHYTOSEIIDAE)

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Abstract

The life-history parameters of *Phytoseius plumifer* (Canestrini & Fanzago) were studied in the laboratory using immature stages of the two-spotted spider mite *Tetranychus urticae* Koch as a food source at seven temperature degrees (15±1ºC - 35±1ºC). Life cycle (egg – adult emergence) lasted for 33.3, 16.6, 9.6, 8.7, 7.9, 7.4, and 7.1 days when female was maintained at 15, 20, 25, 28, 30, 32, and 35ºC, respectively, and 70% R.H. Mean daily oviposition increased as temperature increased till reaching 32ºC (2.0 eggs). The intrinsic rate of natural increase (rm) reached its maximum value (0.241 individuals / female / day) at 32ºC. This predator was able to survive and reproduce with varying degrees of fecundity and predacious ability on the two-spotted spider mite *T. urticae* Koch (adults), the red spider mite *T. cucurbitacearum* (Sayed) (immatures and adults), the citrus brown mite *Eutetranychus orientalis* (Klein) (immatures), the eriophyid ploughman's spikenard gall mite *Eriophyes dioscoridis* Soliman and Abou-Awad (active stages), the whitefly *Bemisia tabaci* (Gennadius) (eggs), the scale insect *Parlatoria zizyphus* (Lucas) (eggs), and the date palm *Phoenix dactylifera* L. (pollen grains).

INTRODUCTION

Recently, IPM program is used to minimize as far as possible the wide use of chemical pesticides. One of the major items in modified control tactics is biological control, in which the role of predators is considered a considerable agent for controlling pests. Determining parameters as reproductive capacity, rate of development and searching capacity lead to a better understanding of a predator's potentiality according the possibility of predicting its ability to keep mite populations below economic damage levels (Helle and van de Vrie, 1974). The role of predacious phytoseiid mites in the control of phytophagous mites in orchards has been the subject of much investigation (McMurtry *et al.*, 1970; Tanigoshi *et al.*, 1983).

In Egypt, the phytoseiid mite, *Phytoseius pulmifer* (C. & F.) was reared by many authors (Zaher *et al.*, 1969; Issa *et al.*, 1974; Rasmy & El-Banhawy, 1974; El-Bagoury & Nasr, 1984; Gomaa & Reda, 1985), but no one tested the effect of different temperature degrees on development and survival of *P. pulmifer.* Therefore, the present study was undertaken to determine the development, reproduction and behavior of *P. plumifer* at different constant temperature degrees and 70% R.H. when fed on immature stages of the two-spotted spider mite *Tetranychus urticae* Koch. The developmental threshold levels and population growth rates were estimated.

MATERIALS AND METHODS

Mite cultures: *P. plumifer* stock culture was established by placing a copulated female together with suitable prey on a mulberry leaf *Morus alba* L. situated upside down on cotton wool soaked in water in a 9 cm diameter Petri-dish and left to deposit eggs. The edges of the leaf were also lined with a wet cotton barrier. Leaf was changed by fresh ones when needed (5-7 days). Few drops of water were added daily to the Petri-dish and the culture was kept in room temperature. After-hatching, larvae were fed on the two-spotted spider mite *Tetranychus urticae* Koch as prey and kept to develop and resulted adults to reproduce. When mite number increased, resultant females were spread on other mulberry leaves in Petri-dishes.

Feeding habits: For testing the most suitable food, different associated prey kinds and types as well as date palm pollen grains were used. Eight animal nourishment: the two-spotted spider mite *T. urticae* (immatures and adults), the red spider mite *T. cucurbitacearum* (Sayed) (immatures and adults), the citrus brown mite *Eutetranychus orientalis* (Klein) (immatures), the eriophyid ploughman's spikenard gall mite *Eriophyes dioscoridis* Soliman and Abou-Awad (active stages), the whitefly *Bemisia tabaci* (Gennadius) (eggs), the scale insect *Parlatoria zizyphus* (Lucas) (eggs), and one plant diet, the date palm *Phoenix dactylifera* L. (pollen grains) were evaluated to determine the ability of *P. plumifer* to feed and oviposit on them as a sole food source at 25±1ºC and 70±5% R.H. Newly mated females were separated from the stock culture and effect of different foods on total and daily rate of deposited eggs/female for the 15 days were calculated for each food source at 25±1ºC and 70±5% R.H. Each experiment started with 20 *P. plumifer* females.

Solitary rearing: Newly deposited predator eggs were transferred singly each to a mulberry leaf disc. Each hatched larva was supplied with a known number of fresh suitable prey (*T. urticae* immatures) and kept till progeny reached adulthood, then fe-

males were copulated and left to deposit eggs. Egg hatch and subsequent development rates were recorded twice daily.

Life table parameters: *T. urticae* immatures were used as prey for *P. plumifer* to develop life table parameters at 15, 20, 25, 28, 30, 32, and 35ºC and 70±5% R.H. under 16 hours of cool white fluorescent light (21 umol/SZ/MZ) and 8 hours of darkness. Each tested temperature degree began to be tested with 50 individual predator's eggs. During the developmental period, mortalities of different reared female predator stages were recorded. Eggs of resultant females were collected daily from each female and sex ratio of the progeny was determined. Life table parameters were estimated using the Life 48 computer program (Abou-Setta *et al.*, 1986). Life table parameters of female were calculated separately to obtain a mean and indicate a source of variance for each parameter. It is determined from the formula:

$$\sum_{x}^{\infty} \exp(-rm\ x)\ lx\ mx = 1$$

where: mx is the number of daughters produced per female during the interval x, and lx is the fraction of females alive at age x. The values rm and exp rm (λ) are obtained from the formula. The finite rate of increase, exp rm (λ), is the natural antilogarithm of the intrinsic rate of increase and gives the number of times the population multiplies in a unit of time. The net reproduction rate (Ro) is the rate of multiplication in one generation. T is the mean length of generation time usually expressed in days. These definitions are by Birch (1948).

RESULTS AND DISCUSSION

Feeding habits: Females of *P. plumifer* were able to survive and reproduce on the two-spotted spider mite *T. urticae* (immatures and adults), the red spider mite *T. cucurbitacearum* (immatures and adults), the citrus brown mite *E. orientalis* (immatures), the eriophyid ploughman's spikenard gall mite *E. dioscoridis* (active stages), the whitefly *B. tabaci* (eggs), the scale insect *P. zizyphus* (eggs) and the date palm *P. dactylifera* (pollen grains). Statistical analysis showed that food kinds and types significantly affected female predator fecundity, Table 1 and gave varying degrees of predacious ability. The two-spotted spider mite *T. urticae* immatures resulted in the best results as *P. plumifer* female gave the greatest number of deposited eggs (22.4 eggs), while eggs of the whitefly *B. tabaci* came the least (2.1 eggs).

Influence of temperature on developmental times: The statistical analysis showed that temperature negatively affected the duration of every developmental stage and consequently the total immatures as the duration of each stage decreased with temperature increase for *P. plumifer* fed *T. urticae* (immatures), Table 2. Female life cycle (egg to adult emergence) differed according to temperature degree. The shortest period was at 35ºC (6.8 days), while the longest was at 15ºC (33.3 days). The rate of egg to adult development in phytoseiids generally increases in a linear fashion between 15ºC and 30ºC (Sabelis, 1985). For example, *Galendromus helveolus* (Chant) took 12.4 days to complete development at 18ºC, reduced to 4.6 days at 30ºC (Caceres and Childers, 1991). A developmental maximum of 32ºC was recorded for *Euseius stipulatus* (Athias-Henriot), *Typhlodromus phialatus* Athias-Henriot (Ferragyt *et al.*, 1987). The developmental maximum (35ºC) appeared to be the highest recorded for *P. plumifer* with an average 7.1 days required for life cycle at this temperature, table 3.

Males followed similar trends, but with lower developmental rates throughout ontogeny.

Sex ratio: Temperature affected *P. plumifer* sex ratio as female percentage increased with raise of temperature being 61% at 15ºC, 65% at 25ºC, and 74% at 32ºC and 35ºC, Table 3. This indicated that 32ºC, and 35ºC were the most suitable for giving higher female sex ratio (74%), which consequently resulted in reproduction increase.

Adult female longevity decreased when temperature increased from 15ºC to 35ºC, but the difference in decrease was insignificant between 30ºC and 32ºC. An average female lived for 105.9, 71.8, 45.5, 45.1, 41.5, 41.8, and 33.2 days at 15, 20, 25, 28, 30, 32, and 35ºC, respectively, Table 3. Female fecundity was also positively affected by temperature, but the difference of total eggs were insignificant between 25ºC and 28ºC. The total number of eggs/female increased as temperature increased till reaching 32ºC (52.7 eggs), then it decreased by raising temperature to 35ºC (39.0 eggs).

Reproductive potential: Life table parameters – The effect of temperature on life table parameters is shown in Table 4. The multiplication per generation (Ro) differed according to temperature as this value increased with temperature increase till reaching 32ºC because of greater number of eggs / female and sex ratio, then decreased at 35ºC. Thus, this value averaged 7.9, 22.2, 23.8, 24.7, 31.8, 36.7, and 24.2 times; in a generation time (T) of 58.0, 29.8, 19.7, 17.6, 16.2, 14.9, and 13.2 days at

15, 20, 25, 28, 30, 32, and 35ºC, respectively. Also, the intrinsic rate of natural increase (rm) rose with increasing temperature to 32ºC; while it decreased when temperature exceeded 32ºC. The rm values obtained were 0.035, 0.103, 0.160, 0.181, 0.213, 0.241, and 0.230 individual / female / day; with the finite rate of natural increase (exp rm) (λ) 1.04, 1.11, 1.17, 1.20, 1.24, 1.27, and 1.26 times / female / day at the respective temperatures, when *P. plumifer* fed on *T. urticae* immatures. The age specific female fecundity (mx) and the rate of survival (lx) were shown in Fig. 1. Although the rate of female survival was less at 32ºC than at 30ºC, yet specific rate of fecundity was higher that greatly affected the intrinsic rate of increase (rm).

Thus, it could be concluded that according to different life table parameters and *T. urticae* immatures as prey, temperature degree 32ºC gave the highest reproduction rate (rm = 0.241 individual / female / day) for the predator *Phytoseius plumifer.* Thus, this phytoseiid mite could be considered a good predator of the two-spotted spider mite *T. urticae* in warm countries as well as Egypt.

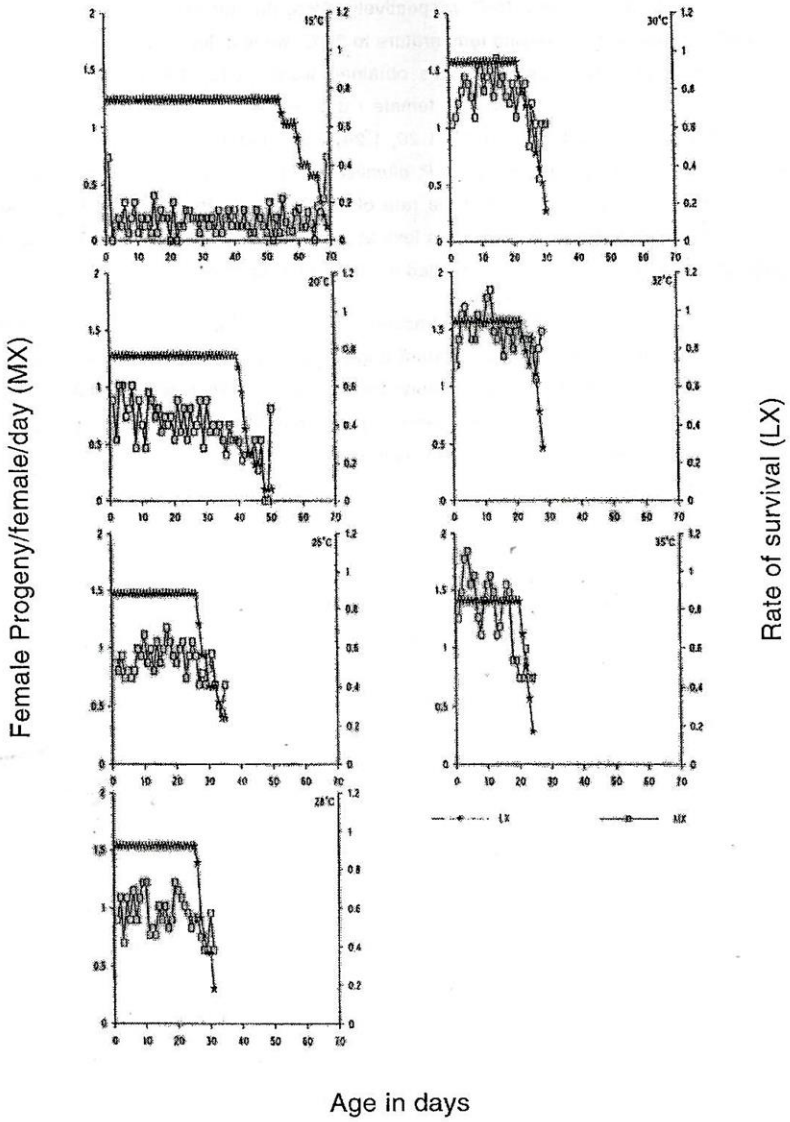

Fig. 1. Age-specific fecundity and survival of *P. plumifer* at different temperatures when fed on *T. urticae* immatures.

Table 1. Fecundity of *Phytoseius plumifer* female fed on different food types at 25°C and 70% R.H. during the first 15 days of oviposition period.

Food type	No. of eggs / female			
	N	Mean	SD	Daily rate
Tetranychus urticae immatures	20	22.4	0.2	1.5
T. urticae adults	20	16.5	0.1	1.1
T. cucurbitacearum immatures	20	19.3	0.2	1.0
Eutetranychus orientalis immatures	20	17.0	0.2	1.1
Eriophyes dioscoridis active stages	20	15.5	0.1	1.0
Bemisia tabaci eggs	20	2.1	0.1	0.1
Parlatoria zizyphus eggs	20	8.4	0.1	0.6
Date palm pollen grains	20	15.1	0.1	1.0

LSD 0.05 for total average = 1.7

N = Number of individuals.

Table 2. Duration in days of different stages of *Phytoseius plumifer* fed on immatures of *Tetranychus urticae* at different temperature degrees and 70% R.H.

Temp.	Female			Male		
ºC	N	Mean	SD	N	Mean	SD
			Egg			
15	28	7.6	1.2	18	7.5	1.1
20	27	4.5	0.5	16	4.3	0.7
25	33	2.7	0.5	16	2.6	0.5
28	34	2.5	0.5	14	2.3	0.5
30	37	2.0	0.6	11	2.0	0.6
32	36	2.0	0.5	13	2.0	0.6
35	35	2.0	0.4	12	2.0	0.2
			Larva			
15	28	2.8	0.7	18	2.4	0.5
20	27	1.4	0.5	16	1.2	0.4
25	33	1.0	0.1	16	1.0	0.2
28	34	0.9	0.2	14	0.9	0.2
30	37	0.8	0.2	11	0.8	0.3
32	36	0.7	0.2	13	0.7	0.3
35	35	0.7	0.3	12	0.7	0.3
			Protonymph			
15	28	11.4	2.4	18	10.5	2.4
20	27	5.2	0.7	16	5.2	0.4
25	33	2.8	0.6	16	2.4	0.5
28	34	2.6	0.5	14	2.6	0.5
30	37	2.5	0.5	11	2.4	0.5
32	36	2.3	0.4	13	2.1	0.3
35	35	2.1	0.6	12	1.8	0.4
			Deutonymph			
15	28	11.4	2.4	18	10.7	2.1
20	27	5.4	0.9	16	5.3	0.9
25	33	3.2	0.4	16	3.0	0.7
28	34	2.8	0.4	14	2.7	0.5
30	37	2.7	0.5	11	2.5	0.5
32	36	2.4	0.5	13	2.4	0.3
35	35	2.3	0.4	12	2.2	0.4

N = Number of individuals.

Table 3. Effect of different temperature degrees on life cycle, adult longevity and fecundity and sex ratio of *P. plumifer* females when fed on *T. urticae* immatures at 70% R.H.

Temp. ºC	Average duration in days*					No. eggs / female		Sex ratio
	Life cycle	Pre – ovi-position	Ovi-position	Post – ovi-position	Longevity	Total average*	Daily rate	++/ total
15	33.3 ± 2.5	11.5 ± 1.2	62.5 ± 5.2	31.9 ± 4.7	105.9 ± 7.2	15.3 ± 3.4	0.2	0.61
20	16.6 ± 0.8	5.3 ± 0.9	42.8 ± 3.4	23.7 ± 2.8	71.8 ± 4.8	36.2 ± 4.8	0.8	0.63
25	9.6 ± 0.9	3.2 ± 0.4	28.1 ± 3.7	14.2 ± 2.4	45.5 ± 3.4	39.8 ± 4.0	1.4	0.65
28	8.7 ± 0.7	2.5 ± 0.7	28.0 ± 2.3	14.6± 2.3	45.1 ± 2.8	41.9 ± 2.8	1.5	0.66
30	7.9 ± 0.8	2.0 ± 0.9	26.3 ± 3.1	13.2 ± 2.5	41.5 ± 3.1	49.0 ± 3.9	1.9	0.69
32	7.4 ± 0.9	2.0 ± 0.5	26.4 ± 1.4	13.4 ± 2.8	41.8 ± 3.5	52.7 ± 4.3	2.0	0.74
35	7.1 ± 1.0	2.0 ± 0.2	22.0 ± 1.5	9.2 ± 1.9	33.2 ± 2.1	39.0 ± 2.8	1.8	0.74

LSD 0.05:
Life cycle = 1.0
Longevity = 3.2
Oviposition = 2.5
Total eggs = 3.0

* Mean ± SD

Table 4. Effect of different temperature degrees on life table parameters of *P. plumifer* when fed on *T.urticae* immatures at 70% R.H.

Parameter	Temperature ºC						
	15	20	25	28	30	32	35
Net reproductive rate (Ro)	7.9	22.2	23.8	24.7	31.8	36.7	24.2
Generation time (days) (T)	58.0	29.8	19.7	17.6	16.2	14.9	13.2
Intrinsic rate of natural increase (rm)	0.035	0.103	0.160	0.181	0.213	0.241	0.230
Finite rate of increase (exp rm) (λ)	1.04	1.11	1.17	1.20	1.24	1.27	1.26
							0.74

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تأثير درجات الحرارة علي مقاييس جداول الحياة للنوع *Phytoseius plumifer*

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تم دراسة تاريخ الحياة للمفترس الأكاروسي *Phytoseius plumifer* (C. & F.) في المعمل بتغذيته علي الأطوار غير الكاملة لأكاروس الحلم العنكبوتي ذي البقعتين *Tetranychus urticae* Koch علي سبعة درجات حرارة من ١٥ – ٣٥°م . بحساب فترة تاريخ الحياة وجد أنها تراوحت بين ٣٣,٣ و١٦,٦ و٩,٦ و٨,٧ و٧,٩ و٧,٢ و٦,٨ يوم علي درجات الحرارة ١٥ و٢٠ و٢٥ و٢٨ و٣٠ و٣٢ و٣٥ °م علي التوالي و درجة رطوبة نسبية ٧٠٪. كما تبين أن معدل وضع البيض اليومي يزداد بارتفاع درجات الحرارة حتى درجة حرارة ٣٢ °م (٢,٠ بيضة) ثم يقل بعد ذلك بارتفاع درجة الحرارة عن ٣٢ °م.

وبحساب جداول الحياة لهذا المفترس الأكاروسي عند تغذيته علي الغذاء المفضل له و هو الأطوار غير الكاملة للحلم العنكبوتي ذي البقعتين *T.urticae* علي درجات حرارة مختلفة ١٥ و٢٠ و٢٥ و٢٨ و٣٠ و٣٢ °م ورطوبة نسبية ٧٠٪. وجد أن معدل الزيادة الذاتي (r m) يصل إلى اعلي معدل له (٠,٢٤١ فرد/ أنثى/ يوم) علي درجة حرارة ٣٢ °م التي يمكن اعتبارها هي الدرجة المثلي لنمو وتكاثر هذا المفترس الأكاروسي .

كما وجد أن هذا المفترس الأكاروسي يمكنه أن يعيش و يتكاثر بدرجات متفاوتة علي الأطوار الكاملة للحلم العنكبوتي ذي البقعتين *T.urticae* و كذلك الأطوار غير الكاملة والكاملة من أكاروس العنكبوت الأحمر العادي النوع الأحمر *Tetranychus cucurbitacearum* (Sayed) والأطوار غير الكاملة و الكاملة لأكاروس الموالح البني *Eutetranychus orientalis* (Klein) والأطوار النشطة للحلم الدودي *Eriophyes dioscoridis* Soliman & Abou-Awad وبيض حشرة النبق القشرية *Parlatoria zizyphus* (Lucas) وبيض الذبابة البيضاء *Bemisia tabaci* (Gennadius) وحبوب لقاح نخيل البلح *Phoenix dactylifera* L.