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INFLUENCE OF TEMPERATURE ON THE LIFE HISTORY AND LIFE TABLE PARAMETERS OF PREDATORY MITE *Phytoseiulus persimilis* ATHIAS-HENRIOT WHEN FED ON TWO SPOTTED SPIDER MITE *Tetranychus urticae* KOCH (ACARI: PHYTOSEIDAE, TETRANYCHIDAE)

Elmoghazy, M. M. E.
Agric. Zoology and Nematology Dept., Fac. of Agric., Al-Azhar Univ., Cairo, Egypt
e-Mail: drelmoghazy@yahoo.com

ABSTRACT

Life history of *Phytoseiulus persimilis* Athias-Henriot when fed on immature stages of *Tetranychus urticae* Koch at 20, 25, 30 and 35 ± 2°C and 65 ± 5 %RH were studied. The total immature stages for female varied from 6.00, 5.54, 4.66 and 4.04 days at the four temperature degrees respectively. The adult longevity female as well as the total life span varied significantly among four temperature degrees (adult longevity: F= 104.95; P < 0.05; total life span: F=127.76; P < 0.05). The mites survived longer at 20°C and oviposited clearly at 25°C than on all other temperature degrees. The number of eggs laid by each female mite exhibited significant differences among four temperature degrees (F= 21.08; P < 0.05) as the total average was 34.33, 43.83, 37.83 and 31.50 eggs/females, also significant variation was observed for the number of eggs laid by each female per day (F= 28.91; P < 0.05) as the daily rate was 1.42, 2.36, 2.27 and 2.16 at 20, 25, 30 and 35 ± 2°C respectively. The analysis of the net reproductive rate (R_o) of *P. persimilis* indicated differences among four temperature degrees. The predator individuals reared at 25°C had the highest R_o value, followed by 30 and 20°C respectively, those at 35°C had the lowest R_o value. The intrinsic rate of natural increase (r_m) and the finite rate of increase (λ) varied at different temperature degrees, best at 25 then 30°C followed by 35°C worst at 20°C. Only the generation time (T) followed a different pattern, being shortest at 35°C and highest at 20°C.

Keywords: Life history, *Phytoseiulus persimilis*, *Tetranychus urticae*, Temperature.

INTRODUCTION

Phytoseiulus persimilis Athias-Henriot was first described by Athias-Henriot in 1954 (Athias-Henriot, 1957). This species is one of the most important predators of the *Tetranychus urticae* Koch. *P. persimilis* is used as a biological control agent for tetranychids worldwide, especially in protected crops (McMurtry and Croft, 1997 and Zhang, 2003). *P. persimilis* has been an efficient biological control agent of the two spotted spider mite *T. urticae* on indoor crops in Europe and North America (Lenteren and van Woets, 1988) and on outdoor crops in California and Florida (McMurtry, 1991). However, the commercially available strains of *P. persimilis* perform poorly in eastern Spain, probably because they are not well adapted to Mediterranean climatic conditions (Nihoul, 1992 and Bakker *et al*., 1993). In Egypt, Rasmy and El-Laithy (1988) and El-Laithy (1992) had introduced *P. persimilis* for biological control of *T. urticae* in greenhouses. Kazak (2006) reported that the females of *P. persimilis* from Hatay completed development in 19.4, 8.3, 5.3, and 4.0 days at 15, 20, 25, and 30 °C when only *T. cinnabarinus* eggs were offered to predators. All *Phytoseiulus* species have a high potential for population increase, probably the highest in the Phytoseiidae (Zhang 1995). They have a short development time (Sabelis and Janssen 1994), with a usually non feeding larval stage that takes up only a small percentage of the developmental period, along with high fecundity, resulting in intrinsic rate of increase (R_o) values sometimes exceeding 0.4 (Takahashi and Chant 1992). However, the rate of increase of *P. persimilis* can vary according to the plant on which the prey, *T. urticae*, is feeding (Popov and Khudyakova, 1989 and Kazak, 2008). With the models from Caswell and Hastings (1980), one can demonstrate that for r_m values higher than approximately 0.1/day a change in developmental time has a larger effect on the population growth rate than an equal proportional change in oviposition rate. For lower r_m values the opposite is true.

The present study throw light on the influence of temperature degrees on the life history and life table parameters of predatory mite *P. persimilis* fed on two spotted spider mite *T. urticae.*

MATERIALS AND METHODS

Maintenance of mite cultures:

Laboratory cultures of the mites were established from field collections of spider mite and phytoseiid made in agricultural crops and weeds. Mite cultures were maintained in separate climatic rooms at 25 ± 2°C, 60: 70 % RH under a 16: 8 h L: D. Predatory mites were reared on detached mulberry leaves prepared as follows. Several young, fully expanded mulberry leaves were placed underside up on a wet cotton wool layer in foil-dishes (20X15 cm in diameter and 2 cm deep).The wet cotton wool prevented mite escape and maintain leaf freshness for a week. The cotton wool was moisten by adding water where necessary. Predatory mites were fed on all the developmental stages for *T. urticae* before the studies at least 30 days.

Thirty discs of fresh mulberry leaves (3 cm diameter) were placed on wet cotton placed in foil-dishes. Every foil-dish contained six discs of mulberry leaves, each disc was surrounded with wet cotton as barrier to prevent mite escape. Newly deposited eggs were transferred singly from stock culture of predator mite to these discs and also immature stages of *T. urticae* were transferred from stock culture as prey. The rearing discs were checked twice daily and the number of consumed preys were recorded and replaced by new ones all over the predator life span. The rearing experiment was carried out at 20, 25, 30 and 35 ± 2ºC and 65 ± 5 % RH in laboratory.

Statistical analysis:

The numerical data collected were computerized by using SPSS program (Statistical Package of Social Science) program, version 16.0.0, 2007**.** Significant differences of *P. persimilis* by temperature degrees were performed by Independent-Samples T test and One-Way ANOVA test ($p < 0.05$). Life table parameters were estimated using the life 48, BASIC computer program (Abu-Setta *et al.,* 1986).

RESULTS AND DISCUSSION

Influence of temperature on developmental periods of female:

The duration of the development of each stage decreased as temperature increased (Table 1). Mean duration of the egg stage (incubation period) of *P. persimilis* was shortened with increasing temperature, and ranged from 2.41, 1.87, 1.83 and 1.75 days at 20, 25, 30 and 35°C, respectively. All larvae, showing the shortest duration compared to other immature stages, which could be attributed to no feed before developing to the protonymph stage. These results were in agreement with (Ashihara *et al*., 1978 and Chittenden and Saito, 2001) who observed that with the exception of larvae, all immature and adult stages *P. persimilis* feed exclusively on tetranychid mite eggs, immature and adult stages. The mean developmental time from egg to adult (life cycle) was affected by temperature. The longest mean developmental time was 8.41 days at 20°C followed by 6.58, 6.50 and 6.25 days at 25, 30 and 35°C, respectively (Table1).

Significant variation among four temperature degrees was observed for the developmental period of *P. persimilis* eggs ($F = 12.451$; $P < 0.05$), while the developmental period of mite larvae showed no significant variation ($F = 2.632$; $P = 0.062$). Mite protonymph and deutonymph showed significant variation ($F = 15.849$; $P < 0.05$) and ($F = 13.223$; $P < 0.05$) respectively. Also, when the total developmental time, i.e. the sum of the three periods above, is compared among four temperature degrees, the variation is significant ($F = 35.276$; $P < 0.05$). The means of these periods are listed in table (1).

Table(1): Duration in days of the developmental stages of *P. persimilis* Athias-Henriot when fed on immature stages of *T. urticae* Koch at 20, 25, 30 and 35 ± 2°C and 65 ± 5 %RH.

Stage		Temperature °C			
		20	25	30	35
Egg	♀	2.41 ± 0.35 a	1.87 ± 0.22 b	1.83 ± 0.24 b	1.75 ± 0.33 b
(incubation period)	♂	2.15 ± 0.24 a	1.75 ± 0.26 b	1.65 ± 0.24 b	1.55 ± 0.28 b
Larva	♀	1.12 ± 0.22 a	1.08 ± 0.19 ac	1.04 ± 0.14 ab	0.91 ± 0.19 b
	♂	1.05 ± 0.15 a	0.95 ± 0.15 ab	0.85 ± 0.24 cb	0.80 ± 0.25 cb
Protonymph	♀	2.25 ± 0.33 a	2.12 ± 0.22 a	1.79 ± 0.33 b	1.37 ± 0.43 c
	♂	1.50 ± 0.40 a	1.40 ± 0.39 ac	1.25 ± 0.26 ac	1.15 ± 0.24 bc
Deutonymph	♀	2.62 ± 0.43 a	2.25 ± 0.26 b	1.83 ± 0.24 c	1.75 ± 0.33 cd
	♂	2.25 ± 0.26 a	2.05 ± 0.15 ac	1.85 ± 0.24 bc	1.65 ± 0.41 bd
Total immatures	♀	6.00 ± 0.63 a	5.54 ± 0.49 b	4.66± 0.32 c	4.04 ± 0.33 d
	♂	4.80 ± 0.42 a	4.40 ± 0.39 b	3.95 ± 0.36 c	3.60 ± 0.51 cd
Life cycle	♀	8.41 ± 0.55 a	6.58 ± 0.59 b	6.50 ± 0.52 b	6.25 ± 0.54 b
	♂	6.95 ± 0.36 a	6.25 ± 0.42 b	5.60 ± 0.39 c	5.15 ± 0.57 d
Longevity	♀	31.08 ± 3.59 a	21.33 ± 1.00 b	19.04 ± 1.40 c	16.66 ± 1.54 d
	♂	28.05 ± 1.81 a	16.15 ± 1.29 b	13.90 ± 0.87 c	11.90 ± 0.99 d
Life span	♀	39.50 ± 3.52 a	27.91 ± 1.27 b	25.54 ± 1.69 c	23.08 ± 1.56 d
	♂	35.10 ± 1.62 a	22.40 ± 1.07 b	19.50 ± 1.13 c	17.05 ± 1.16 d

The values are the Mean ± Std. Deviation ♂ =Male ♀ = Female
Means in a row followed by different letters are significantly different (LSD Test, P < 0.05)

These results were in agreement with Kazak (2008) who observed that duration of all immature stages of females decreased as temperature increased. Life cycle of *P. persimilis* was 7.13 and 7.06 days for female and male respectively when fed on *T. urticae* at 25 ± 2°C and 70 ± 5 %RH (Mohamed and Omar, 2011).

Female longevity and life span:

Duration of preoviposition, oviposition and postoviposition periods, and the longevity of *P. persimilis* females at four temperature degrees are shown in table (2). The preoviposition period at 20°C was the longest 3.75 days compared to 25, 30 and 35°C. The oviposition period was longer at 20°C 24.08 days than that observed at 25, 30 and 35 °C. The oviposition periods at four different temperature degrees were significantly different from each other (Table 2). The postoviposition period at 20°C was longer 3.25 days than that at 25, 30 and 35°C.

The adult longevity of *P. persimilis* as well as the total life span (from egg to death) varied significantly among four temperature degrees (adult longevity: F= 104.95; P < 0.05; total life span: F=127.766; P < 0.05). The mites survived longer at 20°C and oviposited clearly at 25 °C than on all other temperature degrees (Table 2).

Fecundity:

The number of eggs laid by each female mite exhibited significant differences among four temperature degrees (F= 21.08; P < 0.05) as the total average was 34.33, 43.83, 37.83 and 31.50 eggs/females at 20, 25, 30 and 35 ± 2ºC respectively, also significant variation was observed for the number of eggs laid by each female per day (F= 28.91; P < 0.05) as the daily rate was 1.42, 2.36, 2.27and 2.16 at 20, 25, 30 and 35 ± 2°C respectively (Table 2). These results were in agreement with Hoque *et al.,* (2008) who observed that *P. persimilis* could develop and reproduce within a wide range of temperature.

Table (2): Adult female longevity and fecundity of *P. persimilis* Athias-Henriot when fed on immature stages of *T. urticae* Koch at 20, 25, 30 and 35 ± 2°C and 65 ± 5 %RH.

Parameters		20 °C	25 °C	30 °C	35 °C
Average periods (days)	Pre- oviposition	3.75 ± 0.58 a	1.25 ± 0.26 b	1.04 ± 0.25 b	0.95 ± 0.33 b
	Oviposition	24.08 ± 2.64 a	18.58 ± 1.16 b	16. 66 ± 1.15 c	14.58 ± 1.16 d
	Post-oviposition	3.25 ± 1.13 a	1.50 ± 0.36 b	1.33 ± 0.32 b	1.12 ± 0.31 b
	Longevity	31.08 ± 3.59 a	21.33 ± 1.00 b	19.04 ± 1.40 c	16.67 ± 1.54 d
No. of eggs / female	Total average	34.33 ± 3.44 a	43.83 ± 3.90 b	37.83 ± 5.68 c	31.50 ± 2.19 a
	Daily rate	1.42 ± 0.13 a	2.36 ± 0.26 b	2.27 ± 0.39 b	2.16 ± 0.23 b

The values are the Mean ± Std. Deviation
Means in a row followed by different letters are significantly different (LSD Test, P < 0.05)

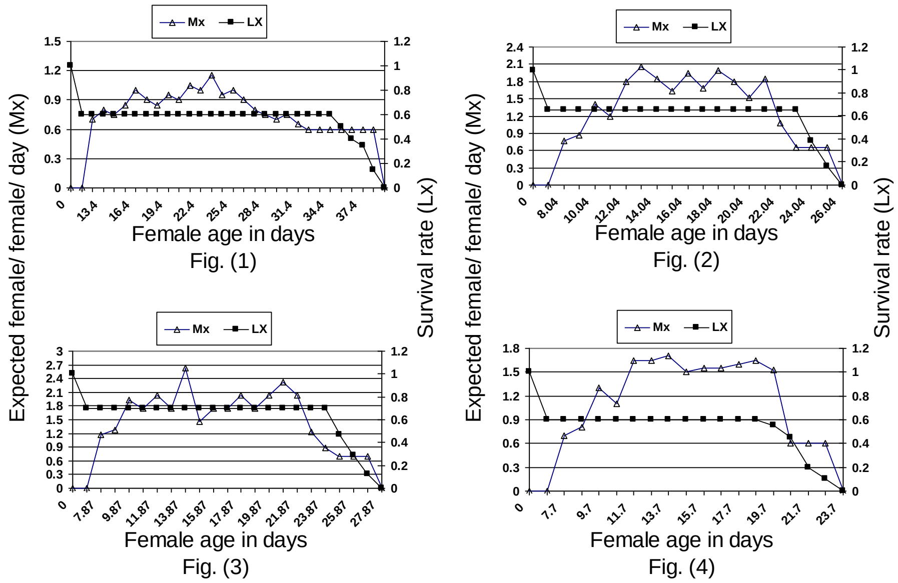
Life table parameters:

The analysis of the net reproductive rate (R_o) of *P. persimilis* indicated differences among four temperature degrees. The predator individuals reared at 25°C had the highest R_o value, followed by 30 and 20°C respectively, those at 35°C had the lowest R_o value. The intrinsic rate of natural increase (r_m) and the finite rate of increase (λ) varied in a different fashion, best at 25 then 30°C followed by 35°C worst at 20°C. Only the generation time (T) followed a different pattern, being shortest at 35°C and highest at 20°C**.** (Table 3 and Figs. 1, 2, 3, and 4).

Table (3): Life table parameters of *P. persimilis* Athias-Henriot when fed on immature stages of *T. urticae* Koch at 20, 25, 30 and 35 ± 2°C and 65 ± 5%RH

Temperature °C	R_o	r_m	λ	T
20	12.36	0.12	1.13	21.25
25	21.47	0.22	1.24	13.86
30	15.98	0.19	1.21	14.28
35	11.34	0.18	1.19	13.38

R_o = Net reproductive rate **T = Generation time**
r_m = Intrinsic rate of increase **λ = Finite rate of increase**



Figs. (1, 2, 3 and 4): Natality and survivorship of *P. persimilis* individuals when fed on immature stages of *T. urticae* at 20, 25, 30 and 35 ± 2°C and 65 ± 5% RH respectively.

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تـأثير درجـات الحـرارة المختلفـة علـى معـدلات دورة الحيـاة للمفتـرس الأكاروسـى *Phytoseiulus persimilis* عنــد تغذيتــه علـــى الحلــم العنكبــوتى *Tetranychus urticae*

محمد محمود السيد المغازى

قسم الحيوان الزراعي والنيماتودا - كلية الزراعة - جامعة الأزهر – القاهرة .

تمت دراسة تاريخ حياة المفترس الأكاروسى *Phytoseiulus persimilis* عندما غذّى على الأطوار الغير ناضجة للحلم العنكبوتى *Tetranychus urticae* عند درجات حرارة 20, 25, 30 ،35 ± 2 °م و رطوبة نسبية 65 ± 5٪ . تأثرت فترة الأطوار غير الكاملة للأنثى بدرجات الحرارة حيث تفاوتت تلك الفترة بين6.00, 5.54, 4.66 ، 4.04 يوم في درجات الحرارة الأربع على التوالي. كما أن فترة الطور البالغ للأنثى بالإضافة إلى فترة الحياة الكليّة (من البيضة الى الوفاة) تفاوتت بشكل ملحوظ بين درجات الحرارة المختلفة (فترة الطور البالغ: $F = 104.95$ ؛ $P < 0.05$ ؛ فترة الحياة الكليّة: $F =127.76$ ؛ $P < 0.05$) حيث عاش المفترس أطول عند حرارة 20 °م وباض بشكل أفضل في 25 °م من كلّ درجات الحرارة الأخرى. ظهرت اختلافات هامّة على عدد البيض المنتج من الإناث بين درجات الحرارة الأربعة المختلفة ($F = 21.08$ ؛ $P < 0.05$) حيث كان معدل وضع البيض الكليّ 34.33, 43.83, 37.83, 31.50 بيضة / أنثى ، كذلك كان هناك تأثير ملحوظ على معدل وضع البيض اليومى ($F = 28.91$ ؛ $P < 0.05$) حيث كان 1.42, 2.36, 2.27, 2.16 على درجات حرارة 20, 25, 30, 35 ± 2 °م على التوالي. تحليل النسبة المنتجة الصافية (R_o) أشار إلى الإختلافات بين درجات الحرارة الأربع حيث كانت قيمة (R_o) أعلى عند 25 °م من باقى درجات الحرارة ، تليها 30, 20°م وكانت أقل قيمه لها عند 35 م°. النسبة الجوهرية للزيادة الطبيعية (r_m) والنسبة المحدودة للزيادة (λ) تفاوتت بطريقة مختلفة، أفضل في 25 ثمّ 30, 35 °م وكانت الأقل في 20 °م. وقت الجيل (T) أخذ نمط مختلف، حيث كان أقصر في 35 °م وأستغرق أطول وقت على 20 °م.

قام بتحكيم البحث

أ.د / عمر عبد الحميد نصار	**كلية الزراعة – جامعة المنصورة**
أ.د / عبد الستار محمد متولى	**كلية الزراعة – جامعة الأزهر**