تأثير طور الفريسة للأكاروس *Tetranychus urticae* (Tetranychidae:Acari) في الخصائص البيولوجية للمفترس *Scolothrips sexmaculatus* (Thripidae:Thysanoptera) في ظروف التربية المخبرية

The Influence of Prey Life Stages of *Tetranychus urticae* (Acari:Tetranychidae) on Biological Parameters of the Predator *Scolothrips sexmaculatus* (Thysanoptera:Thripidae) in Laboratory Rearing

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الملخّص

يُعدّ التربس سداسي البقع (Thripidae:Thysanoptera) *Scolothrips sexmaculatus* من المفترسات المهمة لكثير من الحشرات صغيرة الحجم والأكاروسات. نُفذ هذا البحث عام 2011 في مخابر الهيئة العامة للبحوث العلمية الزراعية في سورية بهدف دراسة تأثير طور الفريسة للأكاروس الأحمر ذي البقعتين (Tetranychidae:Acari) *Tetranychus urticae* في الخصائص البيولوجية للتربس المفترس. بينت النتائج أن لطور الفريسة تأثيراً معنوياً في مدة التطور الجنيني، ومدة تطور اليرقات والعذارى للمفترس *S. sexmaculatus*. وكان أسرع معدل لتطور المفترس عند تغذيته على جميع أطوار الفريسة، إذ بلغ متوسط مدة التطور الجنيني، ومتوسط مدة تطور اليرقات، ومتوسط تطور العذراء 5.8 ± 0.13 و 4.8 ± 0.25 و 1.7 ± 0.15 يوماً على التوالي، بالإضافة إلى ذلك حقق هذا النوع من التغذية نسبة مئوية للبقاء بلغت 88 %. بينما سجل أطول فترة لعمر اليرقات والعذراء (12.2±0.13 يوماً)، وأقل نسبة مئوية للبقاء (66 %) عندما غُذي المفترس على بالغات الفريسة. وبلغت أطول مدة لحياة إناث المفترس 53.4 ± 0.16 يوماً، وأعلى معدل خصوبة للإناث 194.4±2.98 بيضة/للأنثى عند تغذية المفترس على جميع أطوار الفريسة.

الكلمات المفتاحية: *Tertanychus urticae*، الخصائص البيولوجية، *Scolothrips sexmaculatus*.

Abstract

The six-spotted thrips, *Scolothrips sexmaculatus* (Pergande) (Thysanoptera: Thripidae) is considered to be an effective predator against small insects and spider mites. A study was conducted during 2011 at the General Commission for Scientific Agricultural Research (GCSAR/ Syria), to investigate the influence of prey stage of the two-spotted spider mite *Tertanychus urticae* (Acari:Tetranychidae) used as a food on certain biological parameters of the predator *S. sexmacultus*. Results indicated that prey stages had a significant influence on egg incubation period, larval and pupal development periods of the predator *S. sexmacultus*. The shortest developmental periods of the predator were obtained when the predator was fed on a mixed diet of all life stages of the prey. Feeding on such a diet, mean egg incubation period, mean larval development period and mean pupal development period were 5.8±0.13, 4.8±0.25 and 1.7±0.15 days, respectively. Percentage of survival of the predator feeding on such a diet was highest at 88%. The longest duration of the combined larval and pupal stages, 12.2±0.13 days and the lowest survival rate at 66% were recorded for

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the predator individuals feeding on adult stage of the prey. The longest female longevity period 53.4±0.16 days, and the .highest fecundity 194.4±2.98 egg/female were recorded when the predator was fed on a diet of all mixed prey stage
Keywords: *Tertanychus urticae*, Biological parameters, *Scolothrips sexmaculatus*.

Introduction

The two-spotted spider mite (TSSM) *Tetranychus urticae* Koch. is an agricultural pest with a global distribution)Van de (vrie *et al*.,1985; Nauen *et al*., 2001 and Stumpf and Nauen, 2002). *T. urticae* is responsible for significant yield losses for many economic crops, vegetables and fruit trees in many countries of the world, and it is difficult to control it with pesticides alone. This is because spider mites can develop resistance to new kinds of acaricides within a few years (Granham and Helle, 1985; Georghiou, 1990). Therefore, it has been an increasing interest in controlling spider mites with biological control agents, such as predatory thrips, acarophagous ladybirds and predatory mites (Chazeau, 1985; McMurtry and Croft, 1997). Scolothrips are the most important predators of spider mites (Priesner, 1950; Lewis,1973; Gilstrap and Oatman, 1976; Chazeau, 1985; Gilstrap, 1995). The six-spotted thrips, Scolothrips sexmaculatus (Pergande) is the most abundant and most natural control agent of spider mites on strawberry (Oatman and McMurtry, 1966), rhubarb (Oatman, 1970) and peach (Rice and Jones, 1972).

In biological control, estimation of the developmental rates, longevity, survival and fecundity of natural enemies are important to understand their population dynamics and to develop pest management plans (Huffaker *et al*., 1999; Roy *et al*., 2002). Developmental rate studies for predators are needed for prediction of their population phenology and dynamics in field and greenhouse crops. In addition, this knowledge will reduce the discrepancies between field and laboratory observations, permitting for formulating of more reliable phenological models (Pakyari, 2011). Demographic studies including life table, reproductive table and stable population parameters have great importance in integrated pest management programs and mass rearing of natural enemies. A life table describes the development, survival and fecundity of a cohort and provides basic data for population growth parameters. A life table may be used to estimate fitness of a population as influenced by various biotic and abiotic factors (Gabre *et al*., 2005). The cohort life table gives the most comprehensive description of the survival, development, and reproduction of a population, and, as such, is fundamental to both theoretical and applied population ecology. The collection of life table data for relevant species at different trophic levels in a food chain is a basic and important task for conservation (Bevill and Louda, 1999) or pest management (Naranjo, 2001). Hassell (1978) pointed out that the inclusion of the predator and prey age structure is an important step in understanding predator-prey relationships.

Life cycle studies for *S. sexmacultus* using different diets will provide the necessary data for its mass production in pest management programs. Therefore, the present study investigated the influence of different mite life stages of the two spotted spider mite *T. urticae* on life cycle of *S. sexmacultus* in order to further elucidate biological properties of the predator and its effectiveness as a biological control agent of the spider mite.

Materials and methods

Laboratory studies were conducted at General Commission for Scientific Agricultural Research (GCSAR), Damascus countryside, Syria in 2011.

Mite and Thrips Colony:

Culture of two-spotted spider Mite TSSM:

A colony of two-spotted spider mite (*T. urticae*) was initiated using individuals originally collected from bean fields (*Phaseolus vulgaris* L. cv. *Tema*) in Damascus countryside in 2010. A mass culture of two-spotted spider mite was maintained on potted bean plants at 25±1°C, 60±10% RH and a photoperiod of 16:8 (L:D) hrs for more than one year.

Culture of Predator:

S. sexmaculatus individuals found associated with *T. urticae* were also collected from bean plants at the same location

and transferred to the laboratory. The predator species was identified, with the aid of a binocular microscope. Predator' populations were maintained for six months before use in experiments (Parvin *et al*., 2010).

Experimental Design:

Bean plants were grown under laboratory conditions without pesticides, then leaf discs (30 mm in diameter) without major veins were cut and served as the test arena, according to the modified leaf-island method (Sengonca and Gerlach, 1983). Each disc was placed upside down on a layer of wet cotton inside a Petri dish (60 mm in diameter). The lids of the Petri dishes had a hole (15 mm in diameter) covered with fine nylon mesh to allow ventilation. Each Petri dish was sealed with parafilm to prevent escape of the insects. To obtain prey eggs, 50 female spider mites from the colony were released onto clean bean leaves kept in Petri dishes (180 mm in diameter) and allowed to lay eggs (approx.500-600 eggs) for 48 h in a climate cabinet at 26±1°C, 60±10% RH after which the female mites were removed. One-day-old thrips adults were transferred onto the bean leaves provided with *T. urticae* eggs every 2 days. The mite females laid their eggs singly in an incision made in the leaf disc with their ovipositor. The eggs were identified as whitish ellipses floating on a greenish background when viewed using transmitted light under a stereomicroscope.

An experiment was carried out in order to standardize the age of the eggs of *S. sexmaculatus* in the laboratory (26± 1°C) , 60±10% RH and a photoperiod of 16L: hrs. by using 30 leaf discs, each one was provided with 20 mite females and one thrips female taken from the stock and three 7-10-day-old thrips male. The thrips male were removed after 12-24 hr from female eclosion.

Fifty one-day-old eggs of *S. sexmaculatus* were kept in a growth chamber for each treatment according to the offered food associated with different life stages of prey (T. *urticae*), which included (eggs, immature stages, adults and all stages), (total=200 replications). Newly hatched 1st instar larvae were transferred individually to fresh leaf discs. Larvae were fed daily with a surplus of eggs of T. urticae (about 100 prey eggs offered daily for each larva; the number of offered prey was higher than the consumption capacity. Immature individuals were transferred to fresh leaf discs every day with the same type of food until emergence of the last adult predatory thrips. The development rate of immature individuals was determined for each treatment by inspecting the Petri dishes once daily and recording the development stage. The different larval instars were determined based on larval size and on the presence of larval exuviae. The number of eggs laid was recorded daily until thrips female died and longevity (from adult emergence to adult death) was determined. At each treatment, approximately 30 females of *S. sexmaculatus* were examined.

The sex ratios were established by incubating, hatching and rearing the progeny to adult stage. The parent female thrips were transferred daily to new leaf discs. Eggs laid every day for all replicates were incubated, hatched and reared to adults. The unhatched eggs were also counted. The experiment continued till the last thrips died. Carey's method (Carey,1993) was used to construct experimental life table parameters of *S. sexmaculatus*. The parameters of life table and fecundity were constructed including the pivotal age for the age class in units of time (X), the number of surviving individuals at the beginning of each age class (lx), the number of alive individuals between age x and x+1 (x.Lx), total number of individual x age units beyond the age x (Tx), the number of individuals dying during the age interval x (dx).

Statistical Analysis: analysis of variance One Way ANOVA was conducted using SPSS 12.0 package to determine statistical differences in all biological parameters among the different stages of prey offered, and means were separated using the LSD Multiple range test at P=0.05 and 0.01 levels.

Results and Discussion

Results indicated that the *T.urticae* stages provided as food had a significant influence on certain biological parameters of the predator *S. sexmacultus*. The shortest development period of the predator was obtained following feeding on mixed diet of all mite stages (13.3 days), whereas the longest development period was 7.5 days for individuals feeding on adult mites (Table 1). Mean larval development and mean pupal development period were 4.8 and 1.7 days respectively when feeding occurred on mixed diet of mite life stages (Table 1).Percentage of survival of individuals fed on such diet was 88%, The longest duration of the combined larval and pupal stages, averaging at 12.2 days and the lowest survival rate of 66% were recorded for individuals fed on adult mites. It follows that the longest period of life cycle

averaging at 18.4 days was recorded for individuals fed on adult mites compared to its corresponding period (13.3 days) for individuals feeding on mixed diet of all mite stages (Table 1).

The longevity and total fecundity were significantly influenced by prey stages (Table 2) and the data showed that adult longevity and female fecundity were longer and higher when the predator was fed on a mixture of all mite life stages. Female longevity was 53.4 and 28.2 days for individuals feeding on a mixed diet of all mite life stages and individuals feeding on adults mites, respectively (Table 2). Total fecundity was 194.4 and 63.4 eggs/female for individuals feeding on mixed diet of all mite life stages and individuals feeding on adult mites, respectively Whereas, total fecundity of females feeding on immature stages and eggs was 90.2 and 77.88 eggs/female, respectively Adults females of *S. sexmaculatus* began laying eggs in 45.8 days with an average pre-oviposition period of 1.1 days.

The duration of oviposition period at adult female *S. sexmaculatus* ranged from 25.1days to a maximum of 45.8 days for individuals feeding on mite adults and mixture of all mite stages, respectively (Table 2). Results also indicate that the stages overlapped during the developmental period., the male adults emerged approximately one day earlier, but lived for a shorter time than females. Male longevity was 21 days, while female longevity was 53.4 days for individuals feeding on a mixture of all mite stages (Table 2). The total mean fecundity was 194.4 eggs/female during 45.8 days for individuals feeding on a mixture of all mite stages (Table 2). The major reproductive parameters; mean eggs per female/day, mean fertile eggs per female/day, gross hatch rate, net fertility rate and net fecundity rate were 4.2, 3.8, 0.92, 177.9 and 194.4 respectively for individuals feeding on a mixture of all mite stages (Table 2).The sex ratio in all treatments depended on the food, it was 1:6.9 for individuals feeding on a mixture of all mite stages and 1:5.2 for individuals feeding on mite adults (Table 2).

The life cycle findings reported in the present study differs with those reported by Parvin *et al*. (2010). They found that the predator required (8.53±0.11) days to complete their life cycle compared with 13.3±0.37 days reported in our study when the predator was fed on all mite life stages. This difference could be explained by the difference in temperature and humidity conditions used for each experiment. Temperature used were 29°C and 25°C, and relative humidity levels were 67.9% and 60% for Parvin et al (2010) and the present study, respectively. Also, total fecundity figures recorded in the present study (194.4 eggs/female,for individuals feeding on a mixed diet of all mite life stages) were higher than those recorded in Coville and Allen study (1977) where total fecundity of *S. sexmacultus* females were 153.8 and 166.8 egg/female at temperature of 25 and 30°C respectively. Also total female fecundity reported in the present study was higher than those reported by Gheibi and Hesami (2011) on a different mite species of the same genus, i.e S. longicornis, On the other hand, the same mite species, when reared at temperature similar to those implemented in the present study, showed higher fecundity Figures (285.2 egg/female) than those reported in the present study (Sengonca and Weigand, 1988) However, another mite species of the same genus, *S. takahashii*, showed lower fecundity figures than those reported in the present study (Gotoh *et al*., 2004). These noticeable differences in fecundity of various species of this genus might be related to various factors related host plant, and environmental conditions set in the different studies.

Table 1. Influence of prey stages on development period means for developmental stages of *S .sexmaculatus.*

Phases of life cycle of predators	Mean developmental period (days) ± SE and range				L.S.D	
	All mite stages	Adults	Immature	Egg	0.01	0.05
Eggs	5.80±0.13^{Aa} (5 - 6)	6.20±0.36^{Aa} (5 - 8)	6.20±0.25^{Aa} (5 - 7)	6.20±0.39^{Aa} (5 - 8)	1.15	0.86
st Instar 1 larva	2.50±0.17^{Aa} (2 - 3)	4.00±0.26^{Bb} (3 - 5)	2.50±0.17^{Aa} (2 - 3)	3.80±0.29^{Bb} (3 - 5)	0.87	0.65
nd Instar 2 larva	2.30±0.15^{Aa} (2 - 3)	3.50±0.17^{Bb} (3 - 4)	2.60±0.16^{Aa} (2 - 3)	3.40±0.22^{Bb} (2 - 4)	0.68	0.51
Larval	4.80±0.25^{Aa} (4 - 6)	7.50±0.22^{Bb} (6 - 8)	5.10±0.23^{Aa} (4 - 6)	7.20±0.13^{Bb} (7 - 8)	0.83	0.62
Prepupa	1.00±0.00^{Aa} (1 - 1)	2.20±0.13^{Cc} (2 - 3)	1.00±0.00^{Aa} (1 - 1)	1.80±0.13^{Bb} (1 - 2)	0.36	0.27
Pupa	1.70±0.15^{Aa} (1 - 2)	2.50±0.17^{Bb} (2 - 3)	2.30±0.21^{ABb} (1 - 3)	2.30±0.15^{ABb} (2 - 3)	0.67	0.50
Larval and pupal	7.50±0.34^{Aa} (6 - 9)	12.20±0.13^{Bd} (12 - 13)	8.40±0.37^{Ab} (7 - 10)	11.30±0.15^{Bc} (11 - 12)	1.04	0.78
Egg-to-Adult	13.30±0.37^{Aa} (12 - 15)	18.40±0.43^{Bc} (17 - 20)	14.60±0.54^{Ab} (12 - 16)	17.50±0.37^{Bc} (16 - 19)	1.66	1.24

Means in each row with the same capital letter are not significantly different (using ANOVA test at p= 0.01).
Means in each row with the same small letter are not significantly different (using ANOVA test at p= 0.05).

Table 2. Influence of prey stages on some biological and reproduction parameters of *S. sexmaculatus*.

Biological and reproduction parameters	*Mean developmental period(days) ± SE and range*				L.S.D	
	All mite stages	Adults	Immature	Egg	0.01	0.05
Pre-oviposition	1.10±0.10^{Aa} (1 - 2)	1.20±0.13^{Aa} (1 - 2)	1.20±0.13^{Aa} (1 - 2)	2.00±0.21^{Bb} (1 - 3)	0.58	0.43
Oviposition	45.80±0.20^{Aa} (45 - 47)	25.10±0.28^{Dd} (24 - 26)	35.30±0.21^{Bb} (34 - 36)	27.00±0.26^{Cc} (28-26)	0.92	0.69
Post-oviposition	5.60±0.16^{Aa} (5 - 6)	1.00±0.00^{Bb} (1 - 1)	1.20±0.13^{Bb} (1 - 2)	1.20±0.13^{Bb} (1 - 2)	0.48	0.36
Total fecundity mean total no.) (of eggs	194.40±2.98^{Aa} (185 - 212)	63.40±1.43^{Dd} (61-70)	90.20±1.34^{Bb} (84 - 97)	77.80±1.86^{Cc} (68 - 85)	7.74	5.77
Mean eggs/day	4.20±0.25^{Aa} (4 - 5)	2.70±0.15^{Bb} (2 - 3)	2.60±0.16^{Bb} (2 - 3)	2.70±0.21^{Bb} (2 - 4)	0.76	0.57

Egg hatching (%)	91.52±0.99^{Aa} (86.00 – 95.10)	81.75±1.71^{Bb} (73.40 - 89.80)	90.40±1.07^{Aa} (84.60 - 94.60)	85.04±1.34^{Bb} (77.65 - 89.70)	5.03	3.75
fertility (mean (hatching eggs	177.90±3.30^{Aa} (165 - 191)	51.80±1.47^{Dd} (46 - 61)	81.60±1.80^{Bb} (73 - 88)	66.10±1.66^{Cc} (58 - 71)	8.4	6.27
Female longevity (days)	53.40±0.16^{Aa} (53 - 54)	28.20±0.25^{Dd} (27 - 29)	39.20±0.49^{Bb} (37 - 41)	30.60±0.37^{Cc} (29 - 32)	1.31	0.98
Male longevity (Days)	21.00±0.21^{Aa} (20 - 22)	8.50±0.17^{Cc} (8 - 9)	12.20±0.25^{Bb} (1 - 13)	8.60±0.16^{Cc} (8 - 9)	0.77	0.58
Generation (period (days	14.40±0.37^{Aa} (20 - 22)	19.60±0.52^{Bc} (18-22)	15.80±0.55^{Ab} (13-18)	19.70±0.21^{Bc} (19 - 21)	1.68	1.25
Sex ratio males:) (females	1:6.92 (1:7.6-1:6.4)	1:5.16 (1:5.8-1:4.6)	1:6.22 (1:6.9-1:5.5)	1:5.52 (1:6.3-1:4.8)	0.51	0.38

Means in each row with the same capital letter are not significantly different (using ANOVA test at p= 0.01).
Means in each row with the same small letter are not significantly different (using ANOVA test at p= 0.05).

Table 3. Influence of prey stages on survival (%) of *S. sexmaculatus* developmental stages.

Prey stages / Life stages of predator	All mite stages		Adults		Immature		Egg	
	l_x	d_x	l_x	d_x	l_x	d_x	l_x	d_x
Eggs	50	4	50	15	50	10	50	11
1 st Instar larva	46	1	35	2	40	1	39	2
2 nd Instar larva	45	1	33	0	39	0	37	0
Prepupa	44	0	33	0	39	0	37	0
Pupa	44	0	33	0	39	0	37	0
Adult	44	0	33	0	39	0	37	0
Mortality (%)	12		34		22		26	
Survival (%)	88		66		78		74	

lx : the number of individuals that enter a specific stage.
dx : the number of individuals dying during a specific stage.

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