Life History Parameters of the Tomato Red Spider Mite *Tetranychus evansi* (Acari:Tetranychidae), Collected in Syria, on Two Solanaceous Plants

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ABSTRACT

The effect of the two host plants *Solanum lycopersicum* and *Solanum nigrum* belonging to the family *Solanaceae* on biological (survival and duration of developmental stages, fecundity and longevity of females and sex ratio) and demographic parameters (*R0*, *G*, *r*m and λ) of *Tetranychus evansi* was studied in the laboratory under controlled conditions: 25 °C ± 0.5°C, 75 ± 10% RH and 16L : 8D. The rise of Intrinsic rate of increase (r_m= 0.242 day^{-1}) of the mite population, and time needed to duplicate population numbers (*D*t= 2.11 day) on *S. nigrum* compared to *S. lycopersicum* (r_m= 0.215 day^{-1}, *D*t= 20.23 day) refers to *S. nigrum* as a favorable host to *T. evansi*.

Key Words: Tetranychidae, *Tetranychus evansi*, Biological Aspects, Demographic Parameters, *Solanum lycopersicum*.

INTRODUCTION

Tetranychus evansi Baker & Pritchard 1960, is a well-known crop pest, In the last two decades this subtropical tomato red spider mite, expanded its geographical distribution and emerged as a major invasive agricultural pest (Navajas *et al.*, 2012). Several researchers consider it to be native to South America (Gutierrez & Etienne, 1986). It was recorded on tomato, egg plant, potato, peanut and various other plants in Mauritius, Texas and Brazil (Silva, 1954; Moutia, 1958; Baker & Pritchard, 1960). Therefore, it spread rapidly throughout the world and becomes an important pest on solanaceous plants. Currently, this pest is well established in the Mediterranean, and considered as a new threat to both outdoor and protected cultivations of solanaceous crops in Africa and the Mediterranean basin, with invasions characterized by a high reproductive output and an ability to withstand a wide range of temperatures (Boubou *et al.*, 2009, 2011). According to the model desined by Migeon (2005) about its distribution in the world, the whole Mediterranean region, the main area where tomato is grown in open fields; and where this species represents a threat, has the potential to be extensively colonized by the mite.

Until now, few studies have been conducted on the biology of *T.evansi*. Gotoh, *et al*(2009); Qureshi *et al.* (1969) assessed the egg-to-adult developmental time and fecundity of a Californian *T. evansi* strain on nightshade (*Solanum douglasii*) leaves, and de Moraes and McMurtry (1987) examined the lower thermal threshold and life-history parameters of the Californian *T. evansi* strain on *S. douglasii*. Bonato (1999) reported the lower thermal threshold and life-history parameters of *T. evansi* from Congo on tomato leaves. Also Gotoh *et al.*, (2010) used a temperature range from 15 to 35 C° to compare seven strains of *T. evansi* originating from different parts of the world, including South America and newly invaded continents,.Hence, information on the life-history of *T. evansi* itself is scarce and fragmentary.

It is becoming increasingly evident that the establishment of effective control strategies requires a detailed knowledge of the biology, genetic structure and geographical variability, of a given species (Roderick and Navajas, 2003).

The objective of the present study was to estimate the severity of *T. evansi* by comparing the effect of its main two hosts (*Solanum nigrum* and *Solanum lycopersicum*) on development and reproduction of this strain, we have detected in Syria.

MATERIALS AND METHODS

Mite rearing and host plant production

Experiments were carried out using descendants of several females taken from a field located in Lattakia (Syria), in which neither acaricides nor insecticides had been applied (*T. evansi* used in this experements was found on nightshade *S. nigrum* at 1/11/2103). Mites were maintained (25 days before starting the experiments) on down-side-up leaf of nightshade and tomato (*S. nigrum* and *S. lycopersicum* respectively) placed on water-saturated cotton mats in glass dishes (200 mm diameter, 20 mm depth) and kept at 25 ± 1°C, 60–70% relative humidity and 16L:8D photoperiod

. Nightshade and tomato plants were cultivated in pots and grown in greenhouse under 20 ± 5 °C and 75 ± 10% RH). Leaf discs were taken from leaves of both plants of the same variety grown under the above-mentioned conditions.

Experimental conditions

Studies were performed at constant temperatures, 25 ± 0.5°C. Leaf discs (4 cm^2) were maintained on water-soaked cotton and replaced when needed, every 3-5 days. All experiments were carried out in an incubator at RH 75 ± 10%. Light (16L: 18D) was provided by fluorescent tubes.

Immatures development and reproduction

Nine to ten females were placed on each leaf disc (ca. 4 cm^2) and after 2 hours, the females and excess eggs were killed to obtain one egg per disc. The eggs were monitored to determine the development and survival rate of immature stages: larva, protochrysalis, protonymph, deutochrysalis, deutonymph and tritochrysalis, respectively, l, q1, p, q2, d and q3. Each individual was examined two-three times a day (at 8:30 a.m., 2:30 p.m. and at 5 p.m.) and the transition from one stage to another was noted.

When a female was in a tritochrysalis stage, two adult males were introduced to the leaf disc for mating. The new adult females were observed at a 24-hr interval to assess the date of first oviposition. The number of eggs laid by each female was recorded daily throughout its life. The female was transferred to a new leaf disc when neaded, and discs with eggs were maintained under the same experimental conditions as for females. The sex ratio was determined on the basis of a count of adults originating from those eggs during the first five days from the oviposition period. Sex ratio was defined as the proportion of females in the progeny. Non-mated females, i.e. producing only males, were not taken into account.

Statistical analysis and Demographic parameters

Data on developmental time, duration of female reproductive periods and fecundity were analyzed using one-way ANOVA). These statistical analyses were performed using PASW ver. 20. Daily age-specific survival (lx) and fecundity rates (mx) were used to generate life-tables. The net reproductive rate (R_0), $R_0=\Sigma l_x m_x$. the mean generation time (T),$T=\sum x l_x m_x/R_0$, the intrinsic rate of natural increase (r_m), r_m = ln R_o/T; the doubling time (Dt) in days Dt= ln $2/r_m$ and the finite rate of increase (λ) was given by $\lambda = e^{rm}$. All these parmeters were calculated using the method recommended by Birch (1948) and Bank *et al.* (2006).

RESULTS AND DISCUSSION

Immatures development and survival rate

The egg-to-adult developmental duration of mite of both sexes was significantly different among the two host plants, according to analysis of variance (ANOVA) (α= 0.05; F = 585.5; df = 109 and p = 0.0004). According to the present *T.evansi* developed faster on *S.nigrum*; developmental time was 9.2 days on *S.nigrum* and 9.6 days on *S.lycopersicum*.

Table 1 shows the duration of each immature stage of *T. evansi.* Total duration of the immature stages of males was slightly shorter than that of females (Table 1). The egg stage was the longest, lasting from 3.7 days on *S. nigrum* to 4.2 on *S. lycopersicum*. The durations of other stages were similar to one another on each of the two hosts, the active larval, protonymph and quiescent deutonymphal stages were slightly longer than other stages. Some immature stages developmental durations displayed significant differences among hosts.

Female development

No significant differences were found in pre-oviposition, oviposition period, post-oviposition period and adult longevity between the two hosts. The statistical analyses revealed differences between treatments for the first oviposition date (α = 0.05, F = 29.929, df = 49 and $p < 0.0001$), total eggs per female (α = 0.05, F = 35.228, df = 49 and $p < 0.0001$) and daily egg production (eggs/female/day) (α = 0.05, F = 22.71, df = 53 and $p < 0.0001$). The total number of eggs laid per female on *S.nigrum* (210.9) was higer than on *S. lycopersicum* (124.8) (Table 2). Daily average of ovipostion followed similar pattern where the maximum was 17.41 eggs per female on *S.nigrum* and 9.16 eggs per female on *S. lycopersicum*, Maximum longevity of 44.9 days was recorded on *S. lycopersicum* and 48.1 on *S. nigrum* (Figs. 1, 2 respectively and Table 2).

Sex ratio

The averge sex ratio over the first 5 days of the oviposition period revealed no significant difference between tratments were found. Sex ratio was higher on *S.nigrum* but no significant difference was found. The number of eggs laid and the survival ratio during the first 5 days was significantly different (α = 0.05, F = 5.844, df = 33 and p = 0.022), (α = 0.05, F = 22.998, df = 33 and $p < 0.0001$) (Table 3).

Demographic parameters

The net reproductive rate (R_0) and the intrinsic rate of natural increase (r_m) were higher on *S. nigrum* than on *S. lycopersicum.* Mean generation

Table (1): Mean (±SD) duration in days of the egg (e), larva (1), protonymph (p), deutonymph (d) and quiescent stages (q1, q2 and q3) of *T. evansi* on nightshade and tomato under constant temperature :25 ± 0.5°C, 75 ± 10% RH and 16L:8D photoperiod

Stage	host					
	Male+female		female		male	
	S.lycopersicum	*S.nigrum*	*S.lycopersicum*	*S.nigrum*	*S.lycopersicum*	*S.nigrum*
e	4.0 (0.2)a	3.9 (0.2)a	4.1 (0.2)a	3.9 (0.2)a	3.9 (0.2)a	4.0 (0.2)a
1	0.9 (0.1)a	0.9 (0.1)a	0.9 (0.1)a	0.9 (0.1)a	0.8 (0.1)a	0.9 (0.1)a
q1	0.9 (0.1)b	0.8 (0.1)a	0.9 (0.1)b	0.8 (0.1)a	0.9 (0.1)a	0.8 (0.1)a
P	0.9 (0.1)b	0.8 (0.1)a	1 (0.1)b	0.8 (0.1)a	0.8 (0.1)a	0.8 (0.1)a
q2	0.9 (0.1)a	0.8 (0.1)a	0.9 (0.1)b	0.8 (0.1)a	0.8 (0.1)a	0.8 (0.1)a
d	1 (0.1)a	1 (0.1)a	1 (0.1)a	1 (0.1)a	1 (0.1)a	0.9 (0.1)a
q3	1.0 (0.2)b	0.9 (0.1)a	1.1 (0.2)b	0.9 (0.1)a	0.9 (0.1)a	0.8 (0.1)a
Egg- adult	9.6 (0.5)b	9.2 (0.5)a	9.8 (0.8)b	9.2 (0.5)a	9.1 (0.3)a	9.1 (0.7)a
N	58	52	41	39	17	13

N = Number of females tested

Durations followed by the same letters within a row are not significantly different. (ANOVA, a = 0.05).

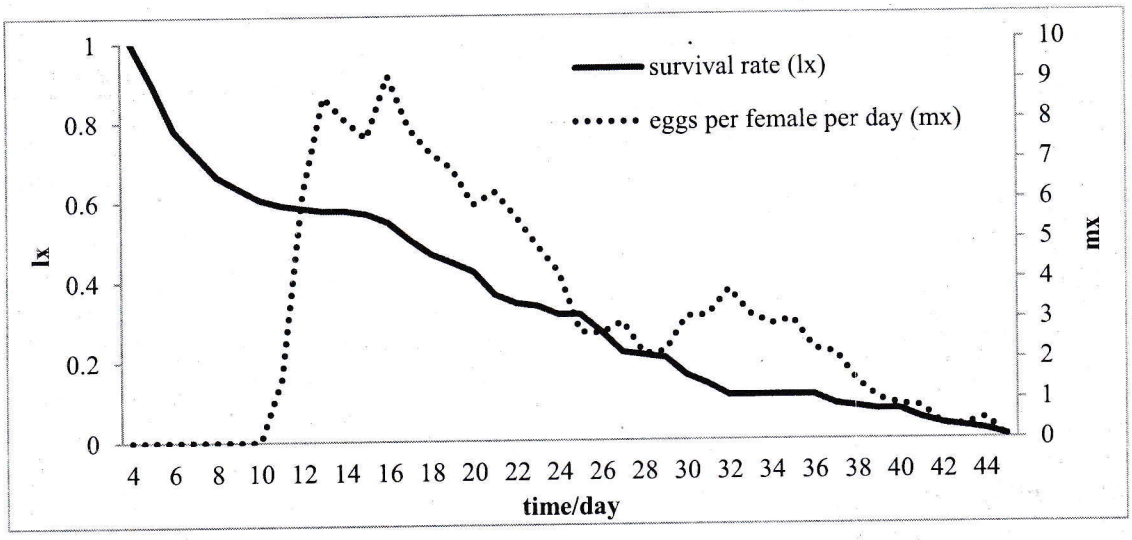

Fig. (1): Age-specific survival rate (lx) and daily fecundity rate (mx) of *T.evansi* on *S.lycopersicum* leaf disc at 25±0.2 °C.

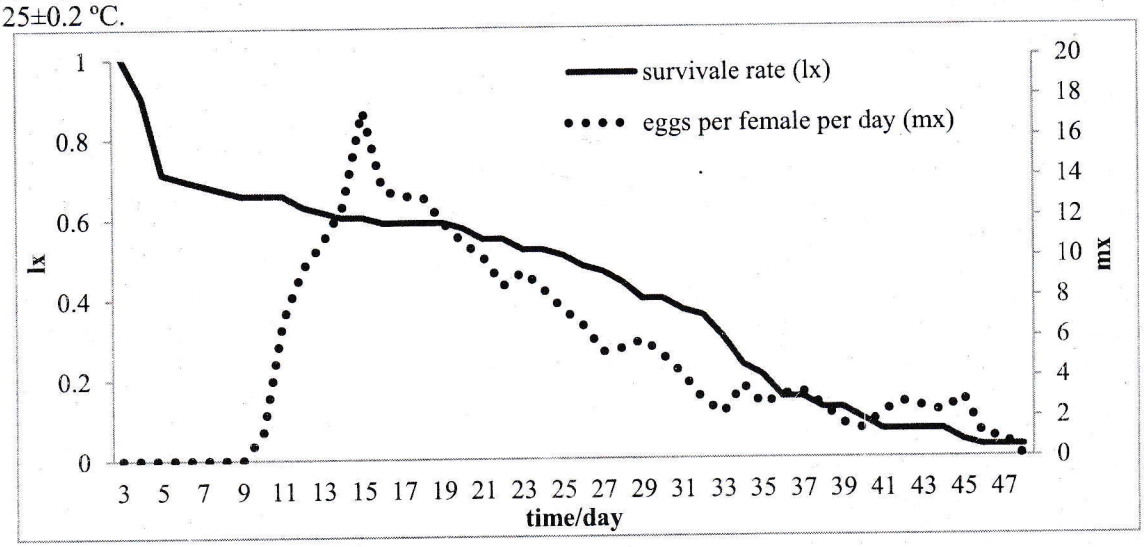

Fig. (2): Age-specific survival rate (lx) and daily fecundity rate (mx) of *T.evansi* on *S.nigrum* leaf disc at 25±0.2 °C.

Table (2): Mean (±SD) duration in days of preoviposition, oviposition and postoviposition periods, longevity and various reproductive parameters: ovipositional rates and peak oviposition rate of *T. evansi*

stage	hosts	
	S. nigrum	*S. lycopersicum*
Pre-oviposition	1.1 (0.2)[a]	1.3 (0.4)[a]
Oviposition	21.8 (7.8)a	19.1 (6.2)[a]
Post-oviposition	1.9 (0.9)[a]	2.5 (1.1)[a]
Longevity	23.7 (5.6)[a]	22.9 (6.6)[a]
Eggs per female per day	6.0 (4.4)[a]	3.7 (2.7)[b]
Total eggs per female	210.9 (60.6)[a]	124.8 (39.9)[b]
Peak oviposition (Oviposition rate)	16 (17.41)	17 (9.71)
First oviposition	9.5	10.2
First death	24.6	20.9
Number of females	27	27

Values in the same row followed by the same letter are not significantly different (ANOV), $\alpha = 0.05$

Table (3): Number of eggs laid during the first 5 days of the oviposition period, hatchability of eggs, survival rate of immature stages and the proportion of females reaching adulthood (mean ± S. D.) on *S.nigrum* and *S.lycopersicum* at 25 °C, 75 % RH and under 16L:8D photoperiod

Host	N	No. of eggs laid	% Hatch	% Survival	% Female
S.lycopersicum	17	43.4 (9.4)a	99.2 (1.3)a	89.4 (5.7)a	88.6 (4.4)
S. nigrum	17	52.6 (12.6)b	99.2 (1.1)a	96.7 (2.6)b	90.3 (4.5)

N = Number of females tested

Durations followed by the same letters within a row are not significantly different.

Table (4): Effect of host plants on age-specific fecundity schedules of *T. evansi* at constant conditions 25 °C, 75 % RH and under 16L:8D photoperiod

hosts	Demographic parameters					
	R_0	G	r_m	λ	*D*t	GRR
S.nigrum	115.43	19.65	0.2417	1.27	2.113	236.89
S.lycopersicum	49.71	18.20	0.2147	1.24	2.232	116.32

time (*T*), finite rate of increase (λ) and doubling time (*D*t) were also different between the two tested hosts (Table 4).

Development from egg to adult at 25C°was faster for the local *T. evansi* strain (9.2 Day) than in the Californian strain used by de Moraes and McMurtry (1987) (13.6 days), and in the seven strains used by Gotoh (2010) (9.7 - 10.7 days) despite the fact that both studies used nightshades as food source. This difference may be due to the age of the eggs used in Gotoh study (0-24 h) and to differences in the observation intervals: in the Gotoh study being every 24 h versus 3 times/ day here when tomato used as a food source. The developmental time was also less in the present study than in the Congo strain used by Bonato (1999) and examined on the same host plants.

Several researchers have studied the reproductive traits of *T. evansi*, and different results were obtained. For the Californian strain on nightshade, de Moraes and McMurtry (1987) reported an oviposition period of 29.0 days at 25C° versus 21.8 days in the present study, thus, the Californian strain had a longer oviposition period than that strain in the present study. For the seven strains in Gotoh study, the oviposition period which he reported was 17.3-23.1 days at 25C°, and the same period for the local strain fell into this range.

The total fecundity of the Californian strain (243 eggs) was much higer than the strain used here (210.9) and the seven strains used in Gotoh study (137-173.5). This may be due to the long oviposition period of the Californian strain.

When tomato was used as a source of food, the present study reported an oviposition period much longer than the Congo strain. The total fecundity followed similar pattern where it was higher in the present study (124.8) than it in the former study(111.1 egg/female). This differences may be resulted from the long oviposition period of the local

syudy and from the difference in the experimental condition of photo period (12:12 in the former study and 16L:8D in the present study), despite that Congo strain examained at 26C°.

Generally, life-table parameters from different studies are difficult to compare, as differences can be due to the organisms as well as the experimental methodology. For instance details of rearing method, environmental conditions other than temperature, and inclusion or exclusion in life-history calculations of aspects such as survival of eggs to adult stage and sex ratio were studded (Bonato, 1999 and Gotoh, 2010). Nevertheless, Sabelis (1985a, 1991), in an extensive review of life-history parameters of tetranychid mites, found the rm-values for *Tetranychus* mites to range from 0.200 to 0.336 day^{-1} at ca. 25°C. The rm-values of *T. evansi* fell within this range. At 25–26°C, the rm-values of various *T. evansi* strains were 0.200 (de Moraes and McMurtry 1987), 0.243 (Bonato, 1999), 0.265-0.277 day^{-1} (Gotoh, 2010), 0.242 day^{-1} on nightshade and 0.215 day^{-1} on tomato in the present study.

These differences in the rm-values may be explained by the lower sex ratio (42.9%) for the Californian strain despite the comparable values of peak oviposition on day 19(de Moraes and McMurtry, 1987), when compared with those of the present study. Contradictory, despite the higher peak oviposition (17.41 eggs on day 16) for the local strain reared on *S. nigrum*, the r_m value here was lower than the seven strains in Gotoh study. This may be due to the reduction of survival ratio lx in the present study when compared with those of Gotoh study.

The r_m value for the local strain reared on tomato was also lower than that of the Congo strain, this may be explained by the high daily oviposition rate 8.2 (egg/female/day) (Bonato, 1999) versus 3.7 (egg/female/day) in the present study.

The rise of Intrinsic rate of increase (r_m) of the mite population, and time needed to duplicate population numbers (*D*t) on *S. nigrum* compared to *S. lycopersicum* refer to *S. nigrum* as a favorable host to *T. evansi* which matches to previous results.This also refers to the examined strain as a relatively less severity one according to not showing same increasing ability once moved from one host (*S. nigrum*) to another (*S. lycopersicum*). Taking in consideration the fact that this strain was raised on (*S. lycopersicum*) a month before starting experiment.

According to genetic researches that mention two Bio-types differ in invasive potential, this difference comes back to other differences in biological characteristics and correlation to botanic host.

The bio-type having a higher invasive potential usually shows up as infection with high mite densities and wide spread, it was mostly found on varied plants of Solanaceae at infected areas like *S. lycopersicum* and *S. melongena* at greenhouses, *Capsicum annuum* and *S. tuberosum* in Algeria. On the other hand, the second bio-type is less truculent, found basically on *S. nigrum* and not showing any intensive infection (Boubou *et al.*, 2011).

Accordingly to this, the local strain found in Latakia area belongs to the bio-type with less invasive potential, that is related to retraction in increasing ability once moved from *S.nigrum* and raised on *S. lycopersicum*. But These evidences don't weighs much taking many reasons in consideration. First, we didn't perform a comprehensive survey to plants surrounding *S.nigrum* and *S. lycopersicum* infested with *T. evansi*. Second, reduction in the mite age-specific fecundity schedules in researches used *S. lycopersicum* as a host compared to using *S. nigrum*, (Bonato, 1999). In addition, genetic analyses researches mentions that biotype with low invasive potential exists in South America and limited areas in France & Catalonian-Spain, while the other bio-type invades the whole Mediterranean basin, eastern Asia countries, and it's the one registered in Palestine. (Boubou, *et al.*, 2009, Boubou *et al.*, 2011).Suppose that the strain exists in research area belongs to the bio typ with low invasive potential, that doesn't really deny the existence of the second bio- type, and refers at the same time that the tow biotypes are exsesting to gether here.

In case the highly invasive potential doesn't exist at the area that suggests intensification of agricultural quarantine procedures to prevent it from invading the area.

Generally, this point needs to perform more expanded researches in terms of widening research area and increasing the number of collected samples, as well as the necessity of starting genetic analyses researches of *T. evansi* populations exists in Syria. Because such steps considered essential and fundamental to formation strategies to resist and controle invading pest which is considered new to Solanaceae crops causing serious damages in the areas recorded at.(Boubou, *et al.*, 2011, Rodrick & Navajas, 2003).

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