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Original article (Orijinal araştırma)

Life table parameters of *Tuta absoluta* (Meyrick, 1917) (Lepidoptera: Gelechiidae) on four wild tomato species

Tuta absoluta (Meyrick, 1917) (Lepidoptera: Gelechiidae)'nın dört yabani domates türü üzerinde yaşam çizelgesi parametreleri

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Abstract

Tuta absoluta (Meyrick, 1917) (Lepidoptera: Gelechiidae) is an important tomato pest that also feeds on other plants in the Solanaceae. The effects of four wild tomato species (*Solanum arcanum* Peralta, *Solanum habrochaites* S.Knapp & D.M.Spooner, *Solanum peruvianum* L., *Solanum pimpinellifolium* L.) and two accession of *Solanum lycopersicum* L. (LA0292 and cv. 112-432) on the life table parameters of *T. absoluta* were determined. Larval development time, lifespan, pupal period, fecundity, and longevity were also estimated. The study was conducted in Isparta University of Applied Sciences, Agriculture Faculty, Plant Protection Department, Isparta, Türkiye in 2020-2021. *Solanum lycopersicum* was the most suitable species for the development of *T. absoluta*. Among the wild tomato species, *S. pimpinellifolium* for intrinsic rate of increase, *S. arcanum,* and *S. pimpinellifolium* for net reproductive rate, *S. habrochaites* and *S. pimpinellifolium* for mean generation time and doubling time*, S. pimpinellifolium* and *S. arcanum* for finite rate of increase were higher than the others. Although the results showed significant differences between the tested wild tomato species, *S. pimpinellifolium* and *S. arcanum* were the most effective wild hosts.

Keywords: Life table, *Solanum*, *Tuta absoluta*, wild tomato species

Öz

Tuta absoluta (Meyrick, 1917) (Lepidoptera: Gelechiidae) önemli bir domates zararlısıdır ve Solanaceae familyasındaki diğer konukçu bitkiler ile de beslenebilmektedir. Bu çalışmada dört yabani domates türü (*Solanum arcanum* Peralta, *Solanum habrochaites* S.Knapp & D.M.Spooner, *Solanum peruvianum* L., *Solanum pimpinellifolium* L.) ve iki *Solanum lycopersicum* L. (LA0292 ve cv. 112-432) aksesyonunun *T. absoluta*'nın yaşam tablosu parametreleri üzerindeki etkileri belirlenmiştir. Ayrıca larva gelişim süresi, yaşam süresi, pupa dönemi, doğurganlık ve yaşam ömrü de hesaplanmıştır. Çalışma Isparta Uygulamalı Bilimler Üniversitesi, Ziraat Fakültesi, Bitki Koruma Bölümü (Isparta, Türkiye)'nde 2020-2021 yılları arasında yürütülmüştür. *Solanum lycopersicum*, *T. absoluta*'nın gelişmesi bakımından en uygun tür olarak belirlenmiştir. Yabani domates türlerinden, kalıtsal üreme yeteneği için *S. pimpinellifolium*, net üreme gücü için *S. arcanum* ve *S. pimpinellifolium*, ortalama döl süresi ve popülasyonun ikiye katlanma süresi için *S. habrochaites ve S. pimpinellifolium*, artış oranı sınırı için *S. pimpinellifolium* ve *S. arcanum* türleri en etkili konukçular olarak belirlenmiştir. Sonuçlar, çalışılan yabani domates türlerinde önemli farklılıklar göstermiş olmasına rağmen *S. pimpinellifolium* ve *S. arcanum* en etkili yabani konukçu türler olarak belirlenmiştir.

Anahtar sözcükler: Yaşam çizelgesi, *Solanum*, *Tuta absoluta*, yabani domates türleri

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Introduction

The tomato leafminer, *Tuta absoluta* (Meyrick, 1917) (Lepidoptera: Gelechiidae), is the main pest in field and greenhouse cultivation of tomato because of the economic damage it causes in growing areas (Biondi & Desneux, 2019). *Tuta absoluta* is on the A1 quarantine list of EPPO (as South American tomato pinworm because the pest was first described in Peru in 1917), and has spread to North African countries and caused serious damage to the tomato growing areas in the region (Desneux et al., 2011). The first record of the pest in Europe was in Spain in 2006 and it spread to all Mediterranean countries including Türkiye within a short time (Kılıç, 2010; Campos et al., 2017). The distribution of pest continued to expand quickly and it is now also found in the majority of European countries, North African countries (Son et al., 2017; Sylla et al., 2017; Mukwa et al., 2021), Middle East countries and Arabian Peninsula (Biondi et al., 2018), Asian countries, especially India and Afghanistan (Han et al., 2019). In infested growing areas, if effective controls are not implemented, it causes 80-100% product losses in tomato plants (Cocco et al., 2013). Due to its fast spread, damage to almost all plant parts and year-round suitable climatic conditions, a highly intense control is made against the pest. The pesticides applied intensively have led to development resistance in the pest populations and caused residue problems in the crops (Gontijo et al., 2013; Guedes et al., 2019). Since chemical control alone is not sufficient, researchers are now focusing on other control techniques, including biological control (Al-Jboory et al., 2012; Zappalà et al., 2013; Gervassio et al., 2019), biotechnological control (Caparros Medigo et al., 2013; Aksoy & Kovancı, 2016) and IPM (Giorgini et al., 2019) techniques, but generally it is concluded that effective control can only be achieved on low pest populations.

Currently, cultivated tomatoes contain only <5% of the genetic diversity of wild species (Miller & Tanksley, 1990). Wild seeds have a high level of genetic diversity compared to modern cultivars (Zhang et al., 2016). Genes cloned from wild relatives have been often used in crossbreeding and molecular studies to improve various crop species (Maxted et al., 2013). Although resistant cultivars have been developed, they could not be a long-term strategy due to the continued use of limited resources, the disease agent rapid adaptation and behavior development of insects. Nowadays, the development of tomato cultivars resistant to biotic factors has been achieved to a great extent by transferring various characteristics from the wild relatives of tomatoes; *Solanum chilense* (Dunal) Reiche (Zamir et al., 1994), *Solanum habrochaites* S.Knapp & D.M.Spooner (Prasanna et al., 2015), *Solanum peruvianum* L. (Seah et al., 2004; Lanfermeijer et al., 2005), *Solanum pennellii* Correll (Parniske et al., 1999) and *Solanum pimpinellifolium* Mill. ex Dunal (Chunwongse et al., 2002).

The life table parameters are an important tool for pest control because they provide a detailed description of the growth, survival and fecundity. This study aimed to determine the life table parameters of *T. absoluta* on wild tomato species and to identify which species showed low growth and reproduction rates. The data obtained in this study include development time, fecundity and survival of *T. absolut*a on four wild tomato species, and two accessions of *Solanum lycopersicum* L. (LA0292 and cv. 112-432).

Materials and Methods

Plant and pest culture

Seeds of *Solanum arcanum* Peralta (LA2152), *S. habrochaites* (LA0094), *S. peruvianum* (LA0445), *S. pimpinellifolium* (LA0100) and *S. lycopersicum* (LA0292) used in this study were obtained from Tomato Genetics Resource Center (tgrc.ucdavis.edu; UC Davis, CA, USA). Tomato plants and *T. absoluta* population were grown in two growth cabinets in Isparta University of Applied Sciences, Agriculture Faculty, Plant Protection Department, Isparta, TÜRKİYE during 2020-2021.

Four wild tomato species and two accessions of *S. lycopersicum* (LA0292 and cv. 112-432; the latter being a commercial cultivar and included as a control in this study) were grown together with the same time and same conditions. All tomato seeds were sized using standard seedling growing practices, and then they were transplanted into 15 × 9 cm pots (4 L) containing a mixture of peat and perlite (1:1). While irrigation and maintenance procedures were applied to all tomato seedlings grown, no chemical fertilizers or pesticides were used. In case of any disease or pest contamination, the damaged part of the plants was removed; if the whole plant was affected, it was immediately removed from the growth cabinet.

Rearing of *Tuta absoluta*

Larvae, pupae and adult samples of *T. absoluta* were collected from infested tomato growing areas and were placed in a climate room. Healthy individuals were selected and applied to commercial tomato plants. To get a stock culture, healthy individuals of *T. absoluta* were reared on cv. 112-432 for at least three generations and then used in experiments.

Survival experiments

All cultures and experiments were kept and conducted in a controlled climate chamber (25±1 ^{o}C; 60±5% RH and 16:18 h L:D photoperiod).

At first, 20 individuals of *T. absoluta* adults taken from the stock culture were placed in net covered plastic boxes (10 × 8 × 8 cm), a complete compound leaf of the tomato species that is suitable for deposition of eggs. To prevent water loss of the tomato leaves, the stem was wrapped with wet cotton and placed in eppendorf tubes containing water. With the daily controls, the eggs contained tomato leaves were transferred into new Petri dishes, and again a clean tomato leaf was left in the plastic boxes containing the adults. The eggs were left on the studied tomato species on the fourth day with leaf parts. After hatching, the larvae were taken into Petri dishes covered with a net together with the leaflet. Each larva considered as a separate replicate. The development and survival of pest species were checked daily. The sexes of individuals were distinguished as male or female at the pupal stage. After determining the sexes, adults were left in plastic boxes with clean tomato leaves with one female and at least two males. A 5% sugar-water solution soaked in blotting paper was placed in the boxes for adult feeding. The tomato leaves were removed from the boxes, and clean tomato leaves of the same species were replaced in the boxes daily. The experiment continued until the last adult died. All treatments had 30 replicates for each plant to give a total 180 replicates.

Life tables analyses

The obtained daily data were analyzed based on the theory of age-stage, two-sex life table (Chi & Liu 1985; Chi, 1988; Chi et al., 2020). According to this theory, calculated parameters:

Age-specific survival rate (l_x), age-specific fecundity rate, age-stage-specific survival rate (the possibility that newly laid eggs will live or exist to age *x* and *j*),

Mean fecundity (F) (eggs/female), $F = \frac{\sum_{x=1}^{N_f} E_x}{N_f}$

Net reproductive rate (R_0) (females/female), $R_0 = \sum_{x=0}^{\infty} l_x . m_x$

Intrinsic rate of increase (*r*) (female/female/day), $1 = \sum_{x=0}^{\infty} \left(e^{-r(x+1)} \sum_{j=1}^{m} f_{xj} s_{xj}\right)$

Mean generation time (T) (day), $T = \frac{lnR_0}{r}$

Gross reproduction rate (GRR) (larvae/female), $GRR = \sum m_x$ (Birch, 1948), Finite rate of increase (λ) (larvae/female/day), $1 = \sum_{x=0}\left(\lambda^{-(x+1)} \sum_{j=1}^{m} f_{xj}\, s_{xj}\right)$

Population doubling time (DT) (day) $DT = \frac{ln\,2}{r}$ (Kairo & Murphy, 1995).

To be used in a comparison test, the mean and standard errors of the *r* values gained from the populations were calculated by the Bootstrap resampling method with the estimates 100,000 times (Meyer et al., 1986; Lawo & Lawo, 2011; Huang & Chi, 2012; Yu et al., 2013a,b). Before the Tukey multiple comparisons test (Tukey, 1949), One-Way ANOVA was applied on the bootstrap values of the intrinsic rates. IBM SPSS Statistics (Version 20.0, August 2011, SPSS Inc., Chicago, IL, USA) and MS Excel 2010 (Version 14.0, June 2010, Microsoft Corporation, Redmond, WA, USA) were used for statistical analyses.

In order to define l_x of tomato leaf miner on different tomato species, a two-parameter Weibull distribution model was used (Deevey, 1947; Pinder et al., 1978; Tingle & Copland, 1989; Wang et al., 2000). The parameters of this distribution model formula:

$$S_p(x) = e^{\left[-\left(\frac{x}{b}\right)^{c}\right]} x, b, c > 0$$

The probability of survival at the age $S_p(x)$ of females in days, b is a scale parameter, and c is a shape parameter. The parameters and curves of Weibull distributions were performed by using SigmaPlot (Version 11.0, Systat Software, Inc., San Jose, CA, USA).

Results

No significant difference was detected between the egg period on control, *S. habrochaites,* and *S. lycopersicum* species; however, there were significant differences between *S. arcanum, S. peruvianum,* and *S. pimpinellifolium* (Table 1). Table 1 shows the developmental times and Figure 1 gives life table graphics of *T. absoluta* on tomato species. The developmental factors of the tomato leafminer were affected by the wild tomato species, especially on larval periods, pupal period and lifespan. The larval period was determined the longest on *S. habrochaites* (43.7 days) and the shortest on control (*S. lycopersicum*) (29.6). Pupal development time of *T. absoluta* was determined the highest on *S. habrochaites* (11.2 days). The shortest pupal period was determined on *S. peruvianum* and control (*S. lycopersicum*) (8.13 and 8.16 days, respectively). Among the experimented host species, the longest lifespan determined on *S. habrochaites,* and the shortest on control (*S. lycopersicum* cv. 112-432) (Table 1).

Table 1. Preadult development periods (mean±SE days)* of *Tuta absoluta* on control (*Solanum lycopersicum* cv. 112-432), *S. lycopersicum* (LA0292) and four wild tomato species

Species	n	Egg		L_1		L_2		L_3		L_4		Pupal period		Lifespan	
Control	30	5.26±0.10	b	4.13±0.15	c	3.93±0.10	d	3.90±0.10	c	4.31±0.10	d	8.16±0.39	c	29.6±0.59	d
S. arcanum	29	5.75±0.09	a	4.69±0.11	ab	5.34±0.18	ab	4.75±0.16	b	9.06±0.33	b	9.62±0.29	b	39.2±0.39	b
S. *habrochaites*	31	5.38±0.08	b	4.35±0.10	bc	5.38±0.17	ab	4.96±0.19	b	12.12±0.50	a	11.3±0.23	a	43.7±0.47	a
S. lycopersicum	31	5.16±0.06	b	4.48±0.12	bc	5.00±0.13	bc	6.16±0.18	a	6.87±0.35	c	10.9±0.33	ab	38.7±0.48	b
S. peruvianum	30	5.43±0.09	ab	4.36±0.08	bc	4.50±0.11	cd	5.86±0.14	a	6.10±0.27	c	8.13±0.33	c	34.4±0.48	c
S. pimpinellifolium	33	5.48±0.08	ab	5.03±0.11	a	5.87±0.17	a	5.18±0.11	b	6.48±0.23	c	10.6±0.35	ab	39.5±0.45	b

* Different letters in each column show significant differences among biological periods at 5% level. (Tukey's HSD test, P > 0.05); (F_{Egg} = 5.04; df = 5,178; P = 0.000; F_{L1} = 7.22; df = 5,178; P = 0.000; F_{L2} = 21.4; df = 5,178; P = 0.000; F_{L3} = 27.769; df = 5,18; P = 0.000; F_{L4} = 70.048; df = 5,177; P = 0.000; F_{Pupa} = 16.842; df = 5,173; P = 0.000; $F_{Lifespan}$ = 101.802; df = 5,1167; P = 0.000).

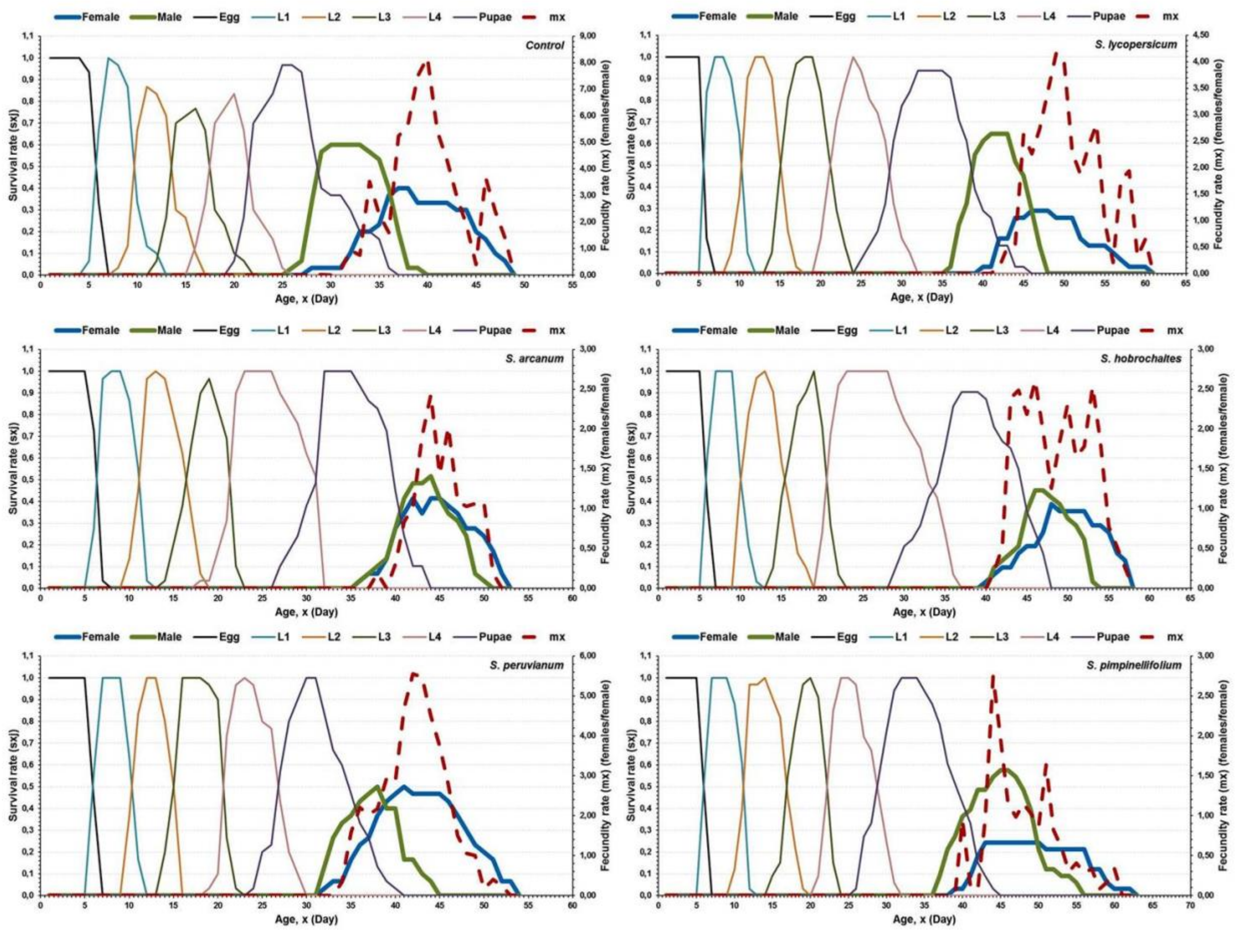

Figure 1. Age-stage-specific survival rate$_j$ and fecundity curves of *Tuta absoluta* on control (*Solanum lycopersicum* cv. 112-432), *S. lycopersicum* (LA0292) and four wild tomato species; *Solanum arcanum*, *S. habrochaites*, *S. peruvianum* and *S. pimpinellifolium*.

There was no significant difference between the oviposition periods of adult tomato leafminer affected by host plants except for *S. arcanum* and *S. habrochaites*. Although the values of adult pre-oviposition periods were similar to each other, statistical differences were observed. However, female adult longevity was not different from each other except for *S. peruvianum.* The shortest total longevity was observed on control (*S. lycopersicum* cv. 112-432) (34.6 days), and the longest was on *S. habrochaites* (46.5 days). The results were not different from the overall longevity on *S. arcanum* (42.3 days) and *S. pimpinellifolium* (43.0 days) (Table 2).

Table 2. Total longevity (days), adult pre-oviposition period (APOP), oviposition and post-oviposition periods, adult (female, male) longevity of *Tuta absoluta* on control (*Solanum lycopersicum* cv. 112-432), *S. lycopersicum* (LA0292) and four wild tomato species

Species	Total longevity*		APOP*		Oviposition period*		Post-oviposition period*		Adult longevity*			
									Female		Male	
Control	34.8±0.77	d	0.83±0.11	a	9.75±0.65	a	0.67±0.19	bc	11.3±0.55	a	8.61±0.22	b
S. arcanum	42.3±0.59	b	1.92±0.16	b	5.00±0.54	b	1.92±0.24	a	8.9±0.68	a	7.60±0.19	c
S. habrochaites	46.5±0.81	a	1.00±0.15	b	5.87±0.88	b	0.93±0.23	abc	9.6±0.60	a	7.26±0.18	c
S. lycopersicum	44.1±0.51	ab	1.10±0.18	b	8.90±1.64	a	0.40±0.22	c	11.6±1.42	a	7.85±0.13	bc
S. peruvianum	38.7±0.71	c	1.93±0.20	a	8.86±1.34	a	1.80±0.20	ab	12.6±1.22	ab	7.60±0.16	c
S. pimpinellifolium	43.0±0.46	b	1.00±0.23	b	9.18±2.06	a	1.63±0.52	ab	16.3±1.25	a	10.63±0.26	a

* Different letters in each column show significant differences among biological periods at 5% level. (Tukey's HSD test, $P > 0.05$; ($F_{Total\ longevity} = 36.481$; df = 5,65; $P = 0.000$; $F_{APOP} = 8.00$; df = 5,72; $P = 0.00$; $F_{Oviposition\ period} = 2.75$; df = 5,72; $P = 0.025$; $F_{Post\text{-}oviposition\ period} = 5.10$; df = 5,72; $P = 0.000$; $F_{Adulu\ female\ longevity} = 6.09$; df = 5,65; $P = 0.000$; $F_{Adult\ male\ longevity} = 41.0$; df = 5,96; $P = 0.000$).

The main fecundity was highest on control (149 eggs/female) and the lowest on *S. arcanum* (43.7 eggs/female) (Table 3). The *r* and finite rates of increase (λ) were the highest on the control (0.086 and 1.09 day^{-1}, respectively). Among the studied tomato species, *S. lycopersicum* had the lowest *r* and λ rates (0.049 and 1.05, respectively). The highest net reproductive rate (R_0) was seen on the *S. peruvianum* with the value of 29.9 (females/female). The lowest R_0 was recorded on *S. pimpinellifolium* (10.5 females/female) and *S. arcanum* (11.0 females/female). Mean generation time (T) and population doubling time (DT) were the shortest on control with the 37.5 and 8.02 days, respectively, and the highest T (47.6 days) and DT (14.0 days) were on *S. lycopersicum* (Table 3).

Table 3. Fecundity and the population parameters (mean±SE)* of *Tuta absoluta* on control (*Solanum lycopersicum* cv. 112-432), *Solanum lycopersicum* (LA0292) and four wild tomato species

	Control		*S. arcanum*		*S. habrochaites*		*S. lycopersicum*		*S. peruvianum*		*S. pimpinellifolium*	
F	149±11.9	a	43.7±6.00	c	63.0±10.25	bc	110±21.6	ab	108±18.6	abc	123±23.9	ab
r	0.086±0.001	a	0.054±0.001	d	0.063±0.001	c	0.049±0.004	f	0.084±0.003	b	0.051±0.002	e
R_0	25.5±0.30	b	11.0±0.13	d	18.8±0.22	c	10.5±0.13	d	29.9±0.28	a	10.5±0.14	d
T	37.5		44.2		46.9		47.6		40.3		45.8	
GRR	58.4		14.6		27.1		35.7		45.2		17.0	
DT	8.02		12.8		11.1		14.0		8.22		13.5	
λ	1.09		1.06		1.07		1.05		1.09		1.05	

* Different letters in each row show significant differences among biological periods at 5% level. (Tukey's HSD test, $P > 0.05$); ($F_F = 6.937$; df = 5, 65; $P = 0.000$; $F_r = 2760$; df = 5, 326; $P = 0.000$; $F_{R0} = 1630$; df = 5,326; $P = 0.000$).

Weibull distribution models were applied to the age-specific survival rate of the tomato leafminer individuals reared on control, *S. lycopersicum* (LA0292), and wild tomato species (Figure 2). When the model and parameters are examined together, control (*S. lycopersicum* cv. 112-432) has the lowest age (day), b and c values.

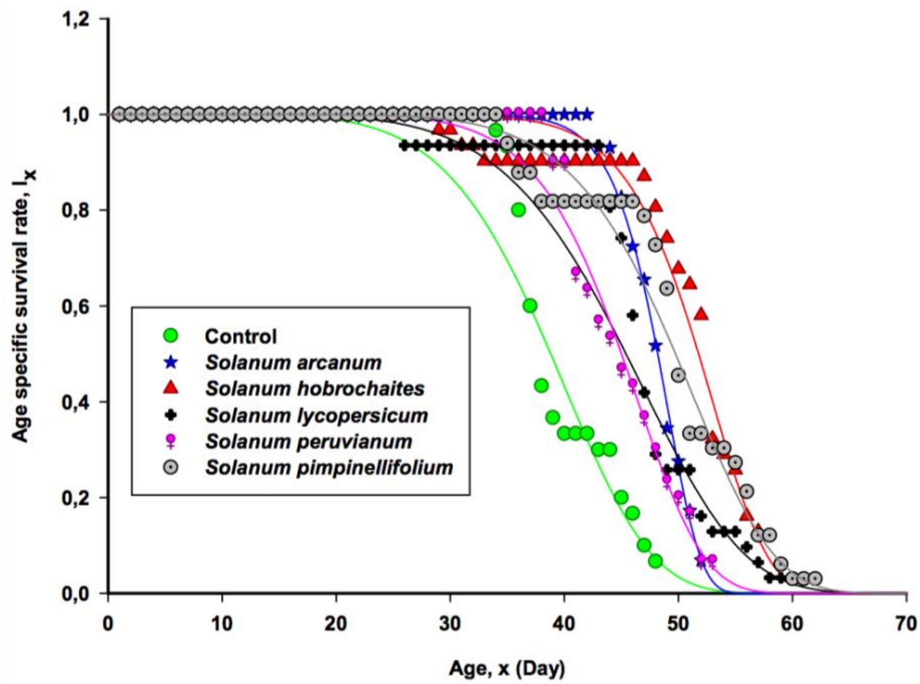

Figure 2. Weibull distribution models applied on the age-specific survival rate (l_x) of *Tuta absoluta* on control and four wild tomato species.

Among the wild species, the highest to the lowest b values were in *S. habrochaites, S. pimpinellifolium, S. arcanum*, and *S. peruvianum*, respectively. When c values are examined, the order was different; the highest to lowest were *S. arcanum, S. habrochaites, S. peruvianum* and *S. pimpinellifolium.*

Considering the values taken by the parameter c determines that the shape of the slope in the modeling, c > 1 indicates a developing population, c = 1 a stable populations and c < 1 a regressed population. When these c values are examined, it is observed that *T. absoluta* population represented an increasing population on four wild tomatoes, *S. lycopersicum* (LA0292) and the control cultivar. R^2 coefficient ranges between 0 and 1 as a measure of the predictive power of a Weibull model. A value closer to 1 indicates that the predictive power of the model has increased. All parameters for the pests on all studied tomato species were effectively predictive (Table 4).

Table 4. Weibull distribution model parameters applied on the age-specific survival rate (l_x) of *Tuta absoluta* on control (*Solanum lycopersicum* cv. 112-432), *S. lycopersicum* (LA0292) and four wild tomato species

Species	b*	c*	R^2	RSS*
Control	41.2±0.25	6.24±0.316	0.975	0.746
Solanum arcanum	49.2±0.04	17.6±0.30	0.999	0.049
Solanum habrochaites	53.4±0.11	11.8±0.48	0.990	0.246
Solanum lycopersicum	48.2±0.31	6.22±0.249	0.973	1.275
Solanum peruvianum	46.9±0.13	8.77±0.273	0.991	0.309
Solanum pimpinellifolium	52.1±0.23	8.06±0.270	0.983	0.856

* Values of parameters b and c are given with their standard errors ($P < 0.0001$). RSS: residual sum of squares.

Discussion

This is the first study of the life tables of the tomato leafminer on different wild tomato species including *S. arcanum* (LA2152), *S. habrochaites* (LA0094), *S. peruvianum* (LA0445), *S. pimpinellifolium* (LA0100). In order to compare the effectiveness of the results, *S. lycopersicum* (LA0292) and control (cv. 112-432) were also used in experiments. There were significant differences on the life table parameters of the pest even between these two *S. lycopersicum* accessions.

Pereyra and Sánchez (2006) reported that *T. absoluta* females laid an average of 133 eggs. The data in this study are similar with our results. However, in another study by Uchoa-Fernandes et al., (1995), it was reported that females can lay up to 260 eggs during their life. This result was much higher than our data but, this may not be due to the difference in tomato species used, but due to the fact that the females mate with only one or two males.

Life tables are very useful tools to determine the susceptible phases of pests and can be used to gain applied and practical information about the population parameters of pests like survival, developmental time and fecundity (Özgökçe & Atlıhan, 2005). In the last decade, tomato leaf miner population parameters have been studied in many times on different tomato cultivars. Erdoğan & Babaroğlu (2014) studied on unknown cultivar of tomatoes in laboratory conditions. They estimated the intrinsic rate of increase (r_m) (0.132 day^{-1}), λ (1.141 day^{-1}), R_0 (42.01) and T (28.3 days) of *T. absoluta.* Gharekhani & Salek-Ebrahimi (2014) studied on three greenhouse cultivars of tomatoes. As a result of their study, they estimated the mean T (23.8, 23.8 and 24.3 days), *r* (0.13, 0.12 and 0.13 day^{-1}), gross reproductive rate (GRR) (35.8, 30.6 and 68.54), R_0 (24.5, 19.2 and 30.5) and mean generation DT (5.18, 5.68 and 4.99) on Atabay, Cluse and Perenses, respectively. Cluse was showed negative influences among the studied species. Çekin & Yaşar (2015) determined r_m as 0.173, 0.169, 0.159 and 0.150 day^{-1} on four tomato cultivars, Torry, Newton, Caracas and Şimşek c.v.s., respectively. Duarte et al. (2015) determined the tomato leaf miner's population parameters on the Cuban tomato (*S. lycopersicum* L.) cultivar Vyta. As a result of their study, the population growth parameters of *T. absoluta*, R_0, T, r_m, DT and λ were 9.36 and 8.90, 5.52 and 5.75, 0.02 and 0.01, 34.6 and 117, and 1.02 and 1.01 at 25 and 20/30ºC, respectively. Rostami et al. (2017) studied population parameter of *T. absoluta* on three cultivated tomatoes, Falkato, Grandella and Isabella. They estimated *r* (0.091, 0.074 and 0.095 day^{-1}), R_0 (15.7, 10.03 and 17.7 offspring), T (30.1, 31.1 and 30.2 days), fecundity (56.2, 45.9, and 59.1 eggs/female), and longevity (26.9, 18.0 and 27.2 days) on Falkato, Grandella and Isabella, respectively. Actually, they recommended that Grandella cultivation would be best in infested areas.

Studies on the population parameters of the studied wild tomato species are limited. Maluf et al. (2010) reported that the total preadult development time of *T. absoluta* showed the slowest development on *S. habrochaites* with 43.7 days. *Solanum habrochaites* was reported to be resistant to *T. absoluta* and other herbivorous pests. Silva et al. (2021) calculated the life table data of *T. absoluta* on six cultivars and four wild species from the Solanaceae family (with only one wild tomato species the same as in our study; *S. habrochaites*). As a result of their study, they determined that the finite rate of increase of *T. absoluta* was 1.15 on the cultured *S. lycopersicum* species and 1.12 on the wild species *S. habrochaites*.

Results of the present study revealed significant differences between population parameters across the examined tomato species. However, it is possible that the control (cv. 112-432) is the most susceptible host for tomato leafminer in terms of preadult development periods, fecundity and population parameters. Among the wild species the longest development periods were determined on *S. pimpinellifolium* in the first and second larval stages and S. *peruvianum* species in the third larval stage. However, the longest lifespan was observed on S. *habrochaites* as fourth larval stage, pupal stage, development time and longevity. The lowest fecundity was observed in *S. arcanum*. In life table parameters, *S. pimpinellifolium* for *r*, *S. arcanum*, *S. pimpinellifolium* for R_0, *S. pimpinellifolium* for T and DT, *S. arcanum* and *S. pimpinellifolium* for GRR was the most susceptible wild tomato species.

These results clearly demonstrate that tomato leaf miner deposits eggs on all host plants, but the effects of the pest were diverse on wild tomato species. There were differences observed on the population parameters between hosts. These differences could be related to insect feeding deterrents present in these wild tomato species. Development of resistant tomato cultivars, by the transfer of resistance factors to commercial cultivars, may be useful in pest management programs for *T. absoluta* (Sohrabi et al., 2016). The most promising genetic sources of resistance are from wild tomato species (Biondi et al., 2018). Firdaus et al. (2012) reported that *S. habrochaites* have a high density of trichome type IV and could be resistant to *Bemisia tabaci* (Gennadius, 1889) (Hemiptera: Aleyrodidae). This trichome structure may have adversely affected the egg-deposition by *T. absoluta*. Trichomes are a common morphological defense against pests; in particular, type IV glandular trichomes have been associated with resistance against different invertebrates. Mata-Nicolás et al. (2021) reported that *S. pimpinellifolium* has a high density of this type of trichomes. Due to close relationship with *S. lycopersicum*, *S. pimpinellifolium* has been recognized the wild progenitor of cultivated tomatoes (Zuriaga et al., 2009; Wang et al., 2020).

In conclusion, commercial tomato cultivars with resistance quantitative trait loci or genes to *T. absoluta* from *S. arcanum* and *S. pimpinellifolium* would be useful in future breeding programs. However, more research is needed on what caused these differences in order to achieve practical applications. Also, these contributing genetic factors in these wild species could be considered as candidates for use in integrated management programs of tomato leaf miner.

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