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Impact of host switching at different larval instars on the performance of the polyphagous pest *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae)

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Tuta absoluta **(Meyrick) (Lepidoptera: Gelechiidae) is a highly adaptable and destructive pest of tomato crops, posing a significant threat to global agriculture due to its rapid spread and resistance to control measures. This study investigates the developmental rates and population parameters of *T. absoluta* larvae when transferred between three host plants—tomato, eggplant, and tobacco—across four distinct larval instars. Larvae were reared under controlled environmental conditions (25 ± 1 °C, 60 ± 5% RH, and 16L:8D photoperiod) and transferred between these hosts at the first to fourth instars. Life table analyses, including parameters such as net reproductive rate (R_0) and intrinsic rate of increase (r), were used to evaluate developmental times, survival, and reproductive potential across different hosts. The results showed that *T. absoluta* could complete its life cycle on all three host plants, although tobacco significantly prolonged the developmental periods, likely due to its high nicotine content, making it a less suitable host. In contrast, tomato supported the most optimal development, while third-instar larvae transferred to eggplant exhibited higher performance than those reared solely on tomato. These findings suggest that *T. absoluta* shows increased adaptability to eggplant at later developmental stages. The study highlights the pest's ability to exploit different hosts, particularly from the third instar onward, and underscores the importance of host selection in shaping pest management strategies. The results have implications for integrated pest management (IPM) approaches, emphasizing targeted interventions based on host plant suitability and developmental stage.**

Keywords *Tuta absoluta*, Tomato, Eggplant, Tobacco, Life table, Pest management

Tuta absoluta (Meyrick) (Lepidoptera: Gelechiidae), commonly known as the tomato leafminer, is a major pest of tomato crops, causing extensive damage and economic losses worldwide. Native to south America and first described in Peru, in 1917, *T. absoluta* has rapidly spread to other continents, including Europe, Asia, and Africa, due to global trade and favorable climatic conditions[1,2]. In 2006, it was detected in Spain, marking its first appearance in Europe, and has since spread at an average rate of 800 km per year[3]. Currently, *T. absoluta* is found throughout South America, most Europe, Africa, the Middle East, the Arabian Peninsula, western Asia, India, Bangladesh, and Myanmar[4]. Its high reproductive capacity, rapid development cycle, and resistance to various insecticides pose significant challenges for effective management[5].

While *T. absoluta* is primarily considered a destructive pest of tomatoes, it has been documented to damage a wide range of plants across several families, including Solanaceae, Convolvulaceae, Chenopodiaceae, Fabaceae, Amaranthaceae, Malvaceae, and Cucurbitaceae[6–8]. In addition to its detrimental effects on cultivated plants, it also damages numerous wild plant species within the Solanaceae family[9,10].

The pest can survive and proliferate year-round in greenhouses or other environments with suitable climates[1,3,11]. *T. absoluta* undergoes four life stages (egg, larval, pupae, and adult), with the larval stage being the

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only ones that consume all plant parts except roots. Adult females lay eggs on leaves, stems, and petioles of host plants. Upon emerging, larvae create tunnels in the leaf epidermal tissue and may also feed on fruits and stems of the host plants[12,13]. The impact of *T. absoluta* on crops is considerable, without effective control measures, potential yield losses can range from 80 to 100%[14,15].

Due to its rapid multiplication and adaptability to various environments, rigorous control measures are necessary. However, extensive pesticide use has led to resistance development in insect populations and residual issues in crops[16,17]. As a result, researchers are exploring alternative strategies, including biological control, biotechnological methods, and mass trapping as part of integrated pest management (IPM) techniques[18–20]. Recognizing that chemical control alone is insufficient, pest management requires a comprehensive approach, especially when pest populations are low.

Life tables provide valuable insights into the development, survival, and fecundity of insects[21–23]. Understanding the behavior and ecology of *T. absoluta* is crucial for developing effective management strategies. One key factor influencing pest dynamics is the host plant. *T. absoluta* is polyphagous, feeding on a variety of hosts, but preferring members of the Solanaceae family, particularly tomatoes[24]. Host plant quality and availability significantly affect the growth, development, and reproductive success of insect pests. Previous studies have shown that host switching in polyphagous pests can lead to variations in growth rates, survival, and fecundity[25]. This study aims to investigate how host switching at different larval instars influences the population dynamics and performance of *T. absoluta*. The results will provide valuable insights for enhancing IPM strategies.

Methods

Plant and pest culture

The solanaceous crops, *Solanum lycopersicum* (cv. Depar), *Solanum melongena* (cv. Anamur), and *Nicotiana tabacum* (cv. White Burley), as well as the *T. absoluta* population, were cultivated in two distinct climate-controlled chambers. These chambers were maintained at a temperature of 25 ± 1ºC, relative humidity of 65 ± 5%, and a photoperiod of 16 h of light and 8 h of darkness. Eggplant plants were sourced as seedlings, while tomato and tobacco seeds were germinated using standard seedling-growing techniques. Following germination, seedlings were transplanted into 15 × 9 cm pots (4 L) filled with a peat and perlite mixture (1:1). Seedlings were irrigated regularly and maintained without the use of chemical fertilizers or pesticides. In the event of disease or pest infestation, affected plants were immediately removed from the chambers to prevent contamination.

Samples of *T. absoluta* larvae and pupae were collected from infested tomato greenhouses in Antalya, Türkiye, and placed in a climate chamber set at 25 ± 1 °C temperature, 65 ± 5% relative humidity, and a photoperiod of 16 h of light and 8 h of darkness. A stock culture was established using healthy individuals, which were reared on tomato plants and used for subsequent experiments.

Survival experiments

Twenty *T. absoluta* adults were randomly selected from the stock culture and placed in a plastic container (10 × 8 × 8 cm) to oviposit on tomato plant leaves. The stems of the leaves were inserted into Eppendorf tubes with cotton containing water. Eggs laid on the leaves were collected and transferred into Petri dishes, and clean tomato leaves were left in the plastic boxes again with daily checks. On the fourth day, the leaf particles laid with eggs were returned to the tomato plants for continued development.

Larval development was monitored daily, and larvae were collected from tomato plants on the first day of each larval instar. Larvae were then transferred to tomato, eggplant, and tobacco plants in line with the study's objectives. At each larval instar, thirty larvae were transferred per host plant, resulting in a total of 120 replicates for each plant. The transfer treatments were: tomato to tomato, tomato to eggplant, and tomato to tobacco. Larvae were monitored daily in Petri dishes covered with nets and equipped with a sponge-covered petiole. Survival data were recorded in Excel spreadsheets.

Sex differentiation of individuals was identified as male or female at the pupal stage[26]. Adults were kept in net-covered plastic boxes. Each box contained one female and at least two males, along with fresh host plant leaves for oviposition. A 5% sugar solution soaked in blotting paper provided nourishment, and host plant leaves were replaced daily. The experiment continued until the death of the last adult. Survival experiments were conducted under climate-controlled conditions (25 ± 1 °C, 60 ± 5% RH, and 16 h light, 8 h darkness).

Life table analyses

Life tables were constructed using daily data according to the age-stage theory and the two-sex life table methodology[27,28]. The calculated parameters included:

Age specific survival rate (l_x),
Age specific fecundity rate (m_x),
Net reproductive rate $R_0 = \sum_{x=0}^{\infty} l_x.m_x$ (female/female),
Intrinsic rate of increase (r), $1 = \sum_{x=0}^{\infty}\left(e^{-r(x+1)}\sum_{j=1}^{m} f_{xj}s_{xj}\right)$ (female/female/day),
Mean generation time (T), $T_o = \frac{\ln R_0}{r_m}$ (day),
Gross reproduction rate (GRR), $GRR = \sum m_x$ (larvae/female),
Finite rate of increase (λ), $1 = \sum_{x=0}^{\infty}\left(\lambda^{-(\mathrm{x}+1)}\sum_{j=1}^{m} f_{xj}s_{xj}\right)$ (larvae/female/day),
Population doubling time (day) $T_2 = \frac{\ln 2}{r_m}$ [29].

Mean and standard errors of the intrinsic rate of increase (r) were calculated using the bootstrap resampling method, with 100,000 iterations[30–34]. Tukey's multiple comparison test[35] was applied after one-way ANOVA to compare pseudo-*r*mj values of intrinsic rates. All statistical analyses were performed using IBM® SPSS® Statistics (Version 20.0, SPSS Inc., Chicago, IL, USA) and MS Excel 2010 (Version 14.0).

Results

Development times among different larval instars on tomato hosts revealed significant differences among males ($P < 0.05$) (Table 1). Additionally, a significant difference was noted between male and female development times at the fourth larval instar. The adult lifespan and overall longevity of the pest increased notably from the third larval instar onward (Table 1).

Table 1 presents the developmental stages and lifespan of *T. absoluta* on tomato plants. Development times for the egg stage showed minimal variation between males and females, with females taking 5.00 ± 0.00 days and males taking 4.59 ± 0.11 days. In the pupal stage, a more pronounced difference was observed: females averaged 8.45 ± 0.28 days, while males averaged 6.53 ± 0.22 days, indicating a statistically significant difference.

The mx values show a rapid decline after the first larval instar, with fluctuations observed throughout subsequent stages, particularly in the third larval instar (Fig. 1). Survival rates (lx) remained relatively stable for second and third instar larvae, but declined sharply in the fourth instar. The longest lifespan was observed in larvae transferred between tomato plants at the fourth instar (Fig. 1).

In a subsequent experiment, larvae reared on tomato plants were transferred to eggplant plants at the beginning of each larval instar. The developmental periods were generally extended for larvae transferred to eggplants compared to those that remained on tomato plants. Development times were 4.17 ± 0.008 days for the first larval transfer, 5.70 ± 0.14 days for the second, 6.63 ± 0.24 days for the third, and 8.23 ± 0.40 days for the fourth (Table 2). However, the lifespan and total longevity of larvae transferred to eggplants decreased as the instar at the time of transfer increased, showing a statistically significant difference ($P < 0.05$). Detailed data can be found in Table 2.

Figure 2 shows the life table curves for larvae transferred from tomato to eggplant at different instars. Notably, the mx values of first instar larvae fluctuated significantly, diverging from the patterns observed in other larval stages. The third instar larvae exhibited the longest lifespan after being transferred to eggplant.

Similarly, Table 3 presents developmental data for larvae transferred to tobacco plants. Development times were extended in each larval stage when compared to those on tomato. For example, the developmental time for the first larval instar was 4.00 ± 0.11 days, while the fourth instar took 7.37 ± 0.29 days to complete. The differences observed were statistically significant ($P < 0.05$). Unlike the results for eggplant, tobacco hosts significantly impacted total longevity, with a decrease noted across most stages except for a significant increase observed in the second larval instar (Fig. 3).

In addition to the developmental data, oviposition performance was assessed for female *T. absoluta* individuals reared on different host plants. No statistically significant differences were observed in the adult pre-oviposition period (APOP), oviposition period, or post-oviposition period among females reared on tomato, eggplant, or tobacco (Table 4). This suggests that host plant changes during larval stages did not significantly impact the egg-laying behavior of adult females.

Table 5 summarizes the life table parameters for *Tuta absoluta* larvae transferred to different host plants. The intrinsic rate of increase (r) was highest for third-instar larvae transferred to eggplant plants, followed by those transferred to tomato plants. Statistical analysis of the net reproduction rate (R_0) revealed that third-instar larvae

	I. instar larva on tomato			**II. instar larva on tomato**			**III. instar larva on tomato**			**IV. instar larva on tomato**		
	♀	♂	**Total**	♀	♂	**Total**	♀	♂	**Total**	♀	♂	**Total**
n	11	19	30	10	20	30	7	23	30	8	22	30
Egg period	4.64 ± 0.15a	4.74 ± 0.10a	4.70 ± 0.009	5.00 ± 0.00a	4.50 ± 0.11b	4.67 ± 0.09	5.00 ± 0.00a	4.61 ± 0.10b	4.70 ± 0.09	5.00 ± 0.00a	4.59 ± 0.11b	4.70 ± 0.09
I. instar larva	3.36 ± 0.15a	3.47 ± 0.14a	3.43 ± 0.10	3.40 ± 0.16a	3.40 ± 0.11a	3.40 ± 0.09	3.57 ± 0.20a	3.43 ± 0.11a	3.47 ± 0.009	3.88 ± 0.23a	3.36 ± 0.10a	3.50 ± 0.10
II. instar larva	3.64 ± 0.20a	3.58 ± 0.12a	3.60 ± 0.10	3.90 ± 0.23a	3.80 ± 0.14a	3.83 ± 0.12	3.71 ± 0.18a	3.65 ± 0.10a	3.67 ± 0.09	4.00 ± 0.19a	3.64 ± 0.10a	3.73 ± 0.10
III. instar larva	3.55 ± 0.16a	3.21 ± 0.10a	3.33 ± 0.09	3.60 ± 0.22a	3.50 ± 0.15a	3.53 ± 0.12	3.86 ± 0.14a	3.91 ± 0.18a	3,90 ± 0.14	3.88 ± 0.13a	3.32 ± 0.10a	3.47 ± 0.009
IV. instar larva	4.36 ± 0.20a	3.84 ± 0.19a	4.03 ± 0.15	4.50 ± 0.17a	3.95 ± 0.05b	4.13 ± 0.08	4.57 ± 0.20a	4.22 ± 0.14a	4.30 ± 0.12	5.13 ± 0.30a	4.82 ± 0.17b	4.90 ± 0.15
Pupal period	8.45 ± 0.28a	6.53 ± 0.22b	7.23 ± 0.24	8.60 ± 0.27a	6.65 ± 0.18b	7.30 ± 0.23	9.29 ± 0.36a	7.17 ± 0.27b	7.67 ± 0.28	9.38 ± 0.50a	7.55 ± 0.30b	8.03 ± 0.29
Lifespan	28.00 ± 0.47a	25.37 ± 0.38b	26.33 ± 0.37	29.00 ± 0.30a	25.80 ± 0.17b	26.87 ± 0.32	30.00 ± 0.38a	27.00 ± 0.36b	27.70 ± 0.37	31.25 ± 0.65a	27.27 ± 0.48b	28.33 ± 0.51
Adult lifespan	12,91 ± 0.95a	8.74 ± 0.24b	10.27 ± 0.53	12.90 ± 0.41a	9.00 ± 0.27b	10.30 ± 0.41	16.29 ± 0.92a	8.13 ± 0.30b	10.03 ± 0.71	17.00 ± 1.07a	8.95 ± 0.36b	11.10 ± 0.76
Total longevity	40.91 ± 1.23a	34.11 ± 0.41b	36.60 ± 0.79	41.90 ± 0.43a	34.80 ± 0.36b	37.17 ± 0.68	46.29 ± 0.92a	35.13 ± 0.57b	37.73 ± 1.00	48.25 ± 1.46 a	36.23 ± 0.53b	39.43 ± 1.12

Table 1. Developmental stages and lifespan of *Tuta absoluta* on tomato plants, with transfers between plants (days). Differences between means (± standard errors) with different letters in the same column for each biological period are statistically significant (Boostrapped paired t-test, B: 100,000, $p > 0.05$).

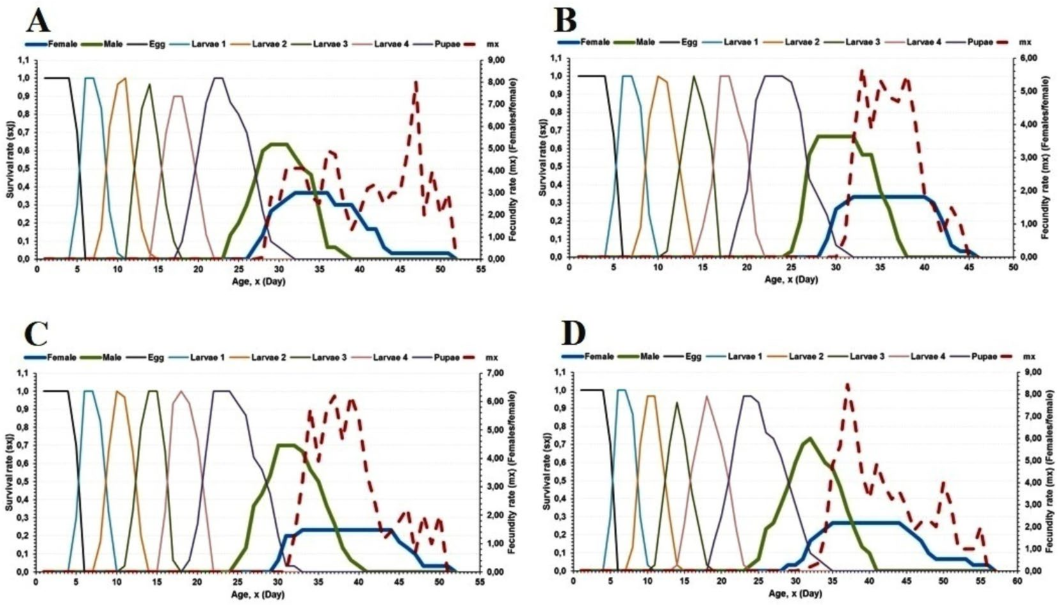

Fig. 1. Life tables of *Tuta absoluta* larvae reared on tomato plants and transferred to tomato plants. (**A**) 1st instar larvae; (**B**) 2nd instar larvae; (**C**) 3rd instar larvae; (**D**) 4th instar larvae.

	I. instar larva on eggplant			II. instar larva on eggplant			III. instar larva on eggplant			IV. instar larva on eggplant		
	♀	♂	Total	♀	♂	Total	♀	♂	Total	♀	♂	Total
n	11	19	30	11	19	30	15	15	30	7	23	30
Egg period	5.27 ± 0.14a	5.53 ± 0.12a	5.43 ± 0.09	4.45 ± 0.16a	4.47 ± 0.12a	4.47 ± 0.09	4.60 ± 0.13a	4.87 ± 0.09a	4.73 ± 0.08	5.00 ± 0.00a	4.83 ± 0.08a	4.87 ± 0.06a
I. instar larva	4.09 ± 0.16a	4.21 ± 0.10a	4.17 ± 0.08	3.64 ± 0.20a	3.53 ± 0.12a	3.57 ± 0.10	4.07 ± 0.07a	3.27 ± 0.12b	3.67 ± 0.10	4.00 ± 0.00a	3.43 ± 0.11b	4.87 ± 0.06
II. instar larva	5.00 ± 0.36a	5.32 ± 0.15a	5.20 ± 0.16	5.82 ± 0.18a	5.63 ± 0.19a	5.70 ± 0.14	3.47 ± 0.13a	3.87 ± 0.19a	3.67 ± 0.12	3.14 ± 0.14a	3.96 ± 0.13b	3.77 ± 0.12
III.instar larva	6.55 ± 0.21a	5.84 ± 0.21b	6.10 ± 0.16	5.91 ± 0.28a	5.84 ± 0.19a	5.87 ± 0.16	7.07 ± 0.32a	6.20 ± 0.33a	6.63 ± 0.24	4.00 ± 0.31a	3.39 ± 0.10b	3.53 ± 0.11
IV.instar larva	9.36 ± 0.56a	8.84 ± 0.43a	9.03 ± 0.34	7.64 ± 0.34a	7.58 ± 0.19a	7.60 ± 0.17	7.60 ± 0.35a	6.40 ± 0.39b	7.00 ± 0.28	9.14 ± 077a	7.96 ± 0.46a	8.23 ± 0.40
Pupal period	8.91 ± 0.64a	7.89 ± 0.29a	8.27 ± 0.30	8.91 ± 0.16a	6.74 ± 0.23b	7.53 ± 0.25	8.40 ± 0.16a	5.87 ± 0.13b	7.13 ± 0.26	9.14 ± 0.40a	6.43 ± 0.16b	7.11 ± 0.27
Lifespan	39.90 ± 0.81a	37.90 ± 0.59b	38.41 ± 0.51	36.36 ± 0.43a	34.06 ± 0.29b	34.90 ± 0.32	35.20 ± 0.43a	30.47 ± 0.65b	32.83 ± 0.58	34.43 ± 0.92a	30.05 ± 0.51b	31.19 ± 0.57
Adult lifespan	11.40 ± 0.58a	7.74 ± 0.17b	9.00 ± 0.40	13.82 ± 0.80a	7.56 ± 0.17b	9.93 ± 0.65	15.20 ± 1.27a	8.13 ± 0.35b	11.67 ± 0.92	14.86 ± 1.42a	8.30 ± 0.16b	10.00 ± 0.67
Total longevity	51.30 ± 0.87a	45.37 ± 0.61b	47.41 ± 0.72	50.18 ± 0.58a	41.61 ± 0.35b	44.86 ± 0.84	50.40 ± 1.27a	38.60 ± 0.62b	44.50 ± 1.30	49.29 ± 1.38a	38.35 ± 0.56b	41.19 ± 1.08

Table 2. Developmental stages and lifespan of *Tuta absoluta* individuals on tomato plants, transferred to eggplant plants (days). Differences between means (± standard errors) with different letters in the same column for each biological period are statistically significant (Boostrapped paired t-test, B: 100,000, $p > 0.05$).

on eggplant had the highest value, with similarly elevated values observed for third-instar larvae on tobacco and second-instar larvae on both tobacco and eggplant.

Similar trends were observed for the finite rate of increase (λ), with third-instar larvae on eggplant again exhibiting the highest values. Larvae on tomato plants across all instars also showed relatively high λ values, although none exceeded those of third-instar larvae on eggplant. The reproductive rate (F) was highest for third and fourth instar larvae transferred to eggplant, with values of 166.12 and 120.76, respectively. This was followed by third-instar larvae on tobacco, which had a value of 114.73. Larvae reared on tomato plants exhibited comparable reproductive rates, with third-instar showing the highest value of 110.75.

Mean generation times (T) increased significantly for larvae transferred to tobacco, particularly for the second and third instars, with values of 46.56 and 43.59 days, respectively. A significant increase was also noted for larvae transferred to eggplant, primarily driven by first instar larvae, which recorded a mean generation

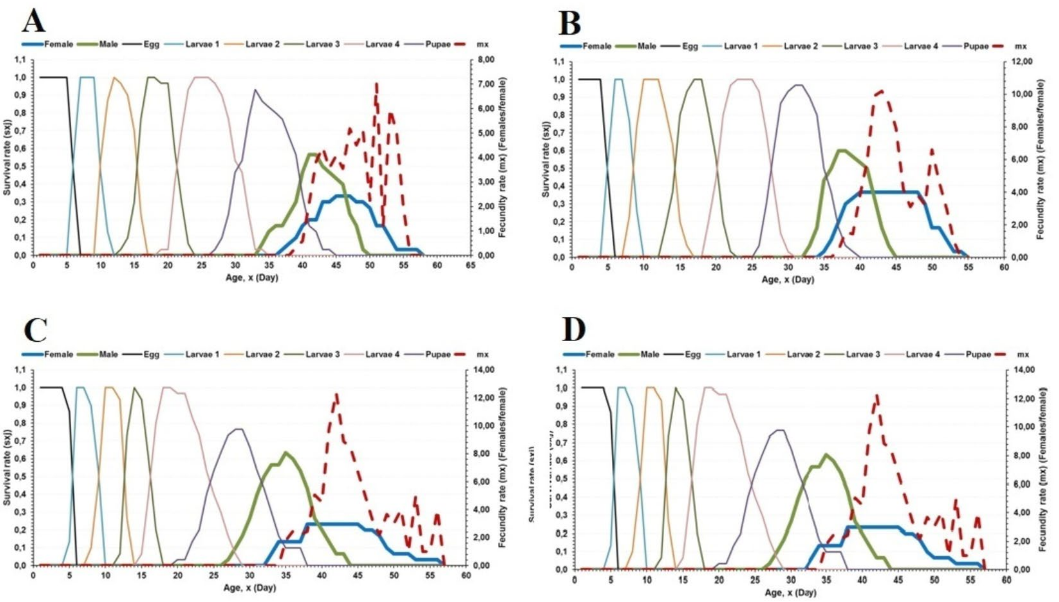

Fig. 2. Life tables of *Tuta absoluta* larvae reared on tomato plants and transferred to eggplant plants. (**A**) 1st instar larvae; (**B**) 2nd instar larvae; (**C**) 3rd instar larvae; (**D**) 4th instar larvae.

	I. instar larva on tobacco			**II. instar larva on tobacco**			**III. instar larva on tobacco**			**IV. instar larva on tobacco**		
	♀	♂	**Total**	♀	♂	**Total**	♀	♂	**Total**	♀	♂	**Total**
n	10	20	30	11	19	30	11	19	30	12	18	30
Egg period	4.70 ± 0.15a	4.25 ± 0.10b	4.40 ± 0.09	5.00 ± 0.00a	5.32 ± 0.11b	5.20 ± 0.07	5.36 ± 0.15a	5.11 ± 0.07a	5.20 ± 0.07	5.67 ± 0.14a	5.11 ± 0.08b	5.33 ± 0.09
I. instar larva	4,10 ± 0.18a	3.95 ± 0.14a	4.00 ± 0.11	4.55 ± 0.16a	4.16 ± 0.09b	4.30 ± 0.09	3.09 ± 0.09a	3.21 ± 0.10a	3.17 ± 0.07	3.67 ± 0.14a	3.56 ± 0.12a	3.60 ± 0.09
II. instar larva	5.10 ± 0.23a	3.80 ± 0.17b	4.23 ± 0.18	7.45 ± 0.21a	5.79 ± 0.14b	6.40 ± 0.19	3.45 ± 0.16a	3.37 ± 0.11a	3.40 ± 0.09	3.00 ± 0.00a	3.44 ± 0.12b	3.27 ± 0.08
III. instar larva	4.90 ± 0.23a	4.85 ± 0.17a	4.87 ± 0.13	5.45 ± 0.31a	4.58 ± 0.12b	4.90 ± 0.15	7.45 ± 0.25a	7.42 ± 0.26a	7.43 ± 0.18	3.67 ± 0.14a	3.56 ± 0.12a	3.60 ± 0.09
IV. instar larva	5.60 ± 0.22a	5.55 ± 0.21a	5.57 ± 0.16	6.64 ± 0.36a	6.63 ± 0.28a	6.63 ± 0.22	9.00 ± 0.70a	7.42 ± 0.29b	7.97 ± 0.33	7.92 ± 0.57a	7.00 ± 0.28a	7.37 ± 0.29
Pupal period	9.78 ± 0.32a	7.63 ± 0.16b	8.32 ± 0.24	10.00 ± 0.29a	7.53 ± 0.19b	8.32 ± 0.27	10.00 ± 0.21a	7.47 ± 0.16b	8.34 ± 0.26	9.13 ± 1.04a	7.06 ± 0.17b	7.69 ± 0.38
Lifespan	34.11 ± 0.54a	30.00 ± 0.56b	31.32 ± 0.55	40.00 ± 0.29a	34.00 ± 0.37b	35.93 ± 0.60	38.20 ± 0.80a	34.00 ± 0.41b	35.45 ± 0.53	35.43 ± 0.30a	29.72 ± 0.33b	31.32 ± 0.58
Adult lifespan	13.89 ± 0.56a	9.47 ± 0.51b	10.89 ± 0.55	14.44 ± 0.53a	10.74 ± 0.37b	11.93 ± 0.45	13.60 ± 0.86a	9.63 ± 0.23b	11.00 ± 0.48	13.57 ± 1.11a	8.39 ± 0.49b	9.84 ± 0.66
Total longevity	48.00 ± 0.75a	39.47 ± 0.69b	42.21 ± 0.92	54.44 ± 0.69a	44.74 ± 0.53b	47.86 ± 0.97	51.80 ± 0.98a	43.63 ± 0.55b	46.45 ± 0.88	49.00 ± 0.98a	38.11 ± 0.48b	41.16 ± 1.09

Table 3. Developmental stages and lifespan of *Tuta absoluta* individuals reared on tomato plants and transferred to tobacco plants (days). Differences between means (± standard errors) with different letters in the same column for each biological period are statistically significant (Boostrapped paired t-test, B: 100,000, $p > 0.05$).

time of 44.88 days. Larvae reared on tomato plants had the shortest mean generation times, indicating more rapid development. Population doubling times (DT) were highest for first-instar larvae transferred to eggplant (9.32 days) and fourth-instar larvae transferred to tobacco (9.04 days). In contrast, larvae transferred between tomato plants exhibited the fastest population doubling times, with third-instar larvae on eggplant showing the shortest doubling time among all groups studied (Table 5).

Discussion

Over the past decade, numerous studies have investigated the population parameters of the tomato leafminer, *Tuta absoluta*, across various tomato cultivars[12,23,36–38]. However, this study is the first to examine the life table of *T. absoluta* larvae reared on tomato plants and subsequently transferred to tomato, eggplant, and tobacco

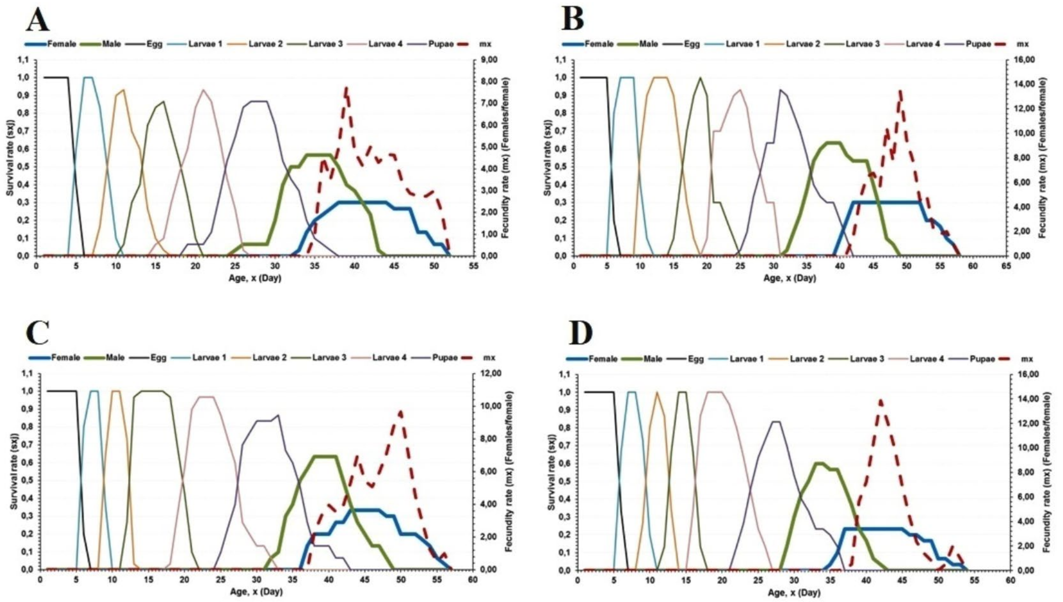

Fig. 3. Life tables of *Tuta absoluta* larvae reared on tomato plants and transferred to tobacco plants. (**A**) 1st instar larvae; (**B**) 2nd instar larvae; (**C**) 3rd instar larvae; (**D**) 4th instar larvae.

		n (♀)	APOP*	Oviposition period	Post-oviposition period
Tomato	I. instar	11	2,63 ± 0,69a	9,54 ± 1,48a	0,72 ± 0,30a
	II. instar	10	1,70 ± 0,21a	10,60 ± 0,45a	0,60 ± 0,16a
	III. instar	7	2,00 ± 0,37a	13,57 ± 0,99a	0,71 ± 0,42a
	IV. instar	8	2,12 ± 0,44a	14,25 ± 0,84a	0,62 ± 0,26a
Eggplant	I. instar	10	1,20 ± 0,13a	9,30 ± 0,68a	0,90 ± 0,31a
	II. instar	11	1,45 ± 0,20a	11,63 ± 0,70a	0,72 ± 0,19a
	III. instar	15	1,13 ± 0,09a	13,73 ± 1,31a	0,33 ± 0,15a
	IV. instar	7	2,14 ± 0,26a	12,42 ± 1,42a	0,28 ± 0,18a
Tobacco	I. instar	9	1,66 ± 0,28a	12,00 ± 0,78a	0,22 ± 0,22a
	II. instar	9	1,55 ± 0,17a	12,88 ± 0,58a	0,00 ± 0,00a
	III. instar	10	1,20 ± 0,13a	12,40 ± 0,90a	0,00 ± 0,00a
	IV. instar	7	1,71 ± 0,42a	11,71 ± 0,74a	0,14 ± 0,14a

Table 4. Duration of pre-oviposition, oviposition, and post-oviposition periods of *Tuta absoluta* individuals transferred to different hosts at different pre-adult stages (days). For each biological period, the difference between the means (± standard errors) indicated with the same letter is not statistically significant (Tukey's HSD test, P < 0,05). *APOP adult pre-oviposition period.

plants at each larval instar. While previous research has largely focused on single-host studies, our investigation into host transfers across developmental stages provides new insights into the adaptability and developmental plasticity of *T. absoluta*.

Our findings indicate that while *T. absoluta* can complete its life cycle on the host plants investigated, different hosts significantly influenced the pest's developmental stages. Notable variations in larval development were observed when *T. absoluta* larvae were subjected to host changes at different larval instars. In particular, third-instar larvae highlighted the pest's adaptability during this crucial period. Larvae transferred to eggplant displayed population parameters suggesting that eggplant may serve as a more suitable host compared to tomato, potentially due to its nutritional composition or its influence on the pest's defense mechanisms.

Conversely, tobacco plants significantly extended the developmental period of *T. absoluta* larvae, indicating a less favorable host. This is likely due to the high nicotine content in tobacco, which acts as a natural insecticide, reducing the pest's survival and reproduction rates. These findings are consistent with previous studies that demonstrated nicotine's potent insecticidal effects[39].

Further analysis of the life table results revealed significant differences in developmental times between larval instars across host plants. Third-instar larvae transferred to eggplant exhibited particularly favorable outcomes, suggesting that *T. absoluta* larvae at this stage benefit from the nutritional richness of eggplant, which may

		n ♀	n ♂	*r* (day^{-1})	R_0 (♀/♀)	λ (day^{-1})	F (eggs/♀)	T (day)	DT (day)
Tomato	I. instar	11	19	0,1017 ± 0,2500 b	28,9162 ± 0,0002 ef	1,1071 ± 0,0014 b	78,8625 ± 0,4135	33,0763 ± 0,7900	6,8145
	II. instar	10	20	0,0938 ± 0,0661 c	25,9195 ± 0,0002 g	1,0984 ± 0,0001 c	77,7586 ± 0,5472	34,6893 ± 0,2622	7,3870
	III. instar	7	23	0,0902 ± 0,0529 d	25,8420 ± 0,0003 g	1,0943 ± 0,0011 d	110,7513 ± 0,6410	36,0731 ± 0,4415	7,6888
	IV. instar	8	22	0,0883 ± 0,0846 e	28,2832 ± 0,0001 f.	1,0923 ± 0,0008 e	106,0621 ± 0,5508	37,8404 ± 0,7325	7,8477
Eggplant	I. instar	11	19	0,0743 ± 0,0853 l	28,1132 ± 0,0001 f.	1,0772 ± 0,0002 l	76,6722 ± 0,3698	44,8782 ± 0,7951	9,3240
	II. instar	11	19	0,0854 ± 0,1274 h	38,4616 ± 0,0002 c	1,0891 ± 0,0002 h	104,8952 ± 0,5632	42,7543 ± 0,3770	8,1199
	III. instar	15	15	0,1082 ± 0,3519 a	83,0623 ± 0,0007 a	1,1142 ± 0,0015 a	166,1245 ± 0,7121	40,8555 ± 0,4216	6,4076
	IV. instar	7	23	0,0820 ± 0,0479 i	28,1770 ± 0,0001 f.	1,0855 ± 0,0010 i	120,7588 ± 0,5372	40,6930 ± 0,9966	8,4488
Tobacco	I. instar	10	20	0,0879 ± 0,0964 f.	32,4185 ± 0,0001 d	1,0918 ± 0,0009 f.	97,2556 ± 0,5472	39,5934 ± 0,7222	7,8891
	II. instar	11	19	0,0783 ± 0,1068 j	38,3217 ± 0,0001 c	1,0815 ± 0,0003 j	104,5138 ± 0,5017	46,5593 ± 0,2940	8,8514
	III. instar	11	19	0,0858 ± 0,1196 g	42,0672 ± 0,0001 b	1,0896 ± 0,0001 g	114,7288 ± 0,4771	43,5901 ± 0,8844	8,0803
	IV. instar	12	18	0,0767 ± 0,0864 k	24,6822 ± 0,0002 b	1,0797 ± 0,0004 k	61,7055 ± 0,3785	41,8148 ± 0,3401	9,0402

Table 5. Life table parameters of *Tuta absoluta* individuals transferred to different hosts at different pre-adult stages. For each biological period, differences between means (± standard errors) indicated with the same letter are not statistically significant (Tukey's HSD test, P < 0,05).

provide a more conducive environment for growth. This observation is consistent with the findings of Galdino et al.[40], who reported that larvae in later instars tend to perform better on nutrient-rich plant parts, likely as an adaptive mechanism to overcome host defenses[37].

In contrast, larvae feeding on tobacco exhibited the longest developmental periods across all larval instars and the pupal stage, consistent with the findings of Jiang et al. [41]. This slower development is likely a consequence of the high nicotine content in tobacco, which reduces survival and reproductive success in *T. absoluta* populations. These results suggest that tomato remains the most suitable host within the Solanaceae family for *T. absoluta*[42,43].

Previous research reported that *T. absoluta* lays an average of 133 eggs, with this number potentially increasing to 260[44,45]. In our study, the number of eggs laid by females was close to this reported average, although significant differences were observed between different hosts and larval instars. The susceptibility of the first and second larval instars to host changes emphasizes the importance of early-stage interventions. Strategies such as removing alternative host plants from areas adjacent to susceptible crops and avoiding the cultivation of other favored hosts near tomato fields could enhance pest control.

Our life table results for larvae transferred to tomato are consistent with previous studies. For example, Erdoğan & Babaroğlu[46] estimated an intrinsic rate of increase (r) of 0.132 day^{-1}, a finite rate of increase (λ) of 1.141 day^{-1}, a net reproductive rate (R^0) of 42.01, and a mean generation time (T) of 28.3 days, closely aligning with our findings for first-instar larvae transferred to tomato plants. Similar trends were observed by Gharekhani & Salek-Ebrahimi [36] across three tomato varieties, where the intrinsic rates of increase (r) ranged between 0.12 and 0.13 day^{-1}, and the net reproductive rates (R^0) varied from 19.2 to 30.5.

Our findings for third-instar larvae transferred to eggplant demonstrate a more favorable outcome for *T. absoluta* compared to tomato, further highlighting the importance of host effects on population dynamics. This aligns with the findings of Çekin & Yaşar[47], who reported that the intrinsic rate of increase for *T. absoluta* was highest on certain tomato cultivars, but variability in these parameters exists when larvae are transferred to other host plants, such as eggplant.

The adaptability of *T. absoluta* across different hosts indicates the need for host-specific management strategies in integrated pest management (IPM) systems. The findings of this study provide valuable insights into the potential risks associated with alternative hosts like eggplant, which may enhance pest survival and reproduction. Conversely, plants like tobacco may offer natural resistance through chemical defenses such as nicotine. Further research is needed to fully explore the implications of these findings.

Conclusion

This study demonstrates that *T. absoluta* exhibits optimal performance and reproductive potential on tomato plants, as evidenced by the highest finite and intrinsic rates of increase, net reproductive rate, and the shortest mean generation and population doubling times. These findings highlight the pest's remarkable adaptability and reproductive capacity on its primary host, tomato. However, when larvae were transferred to alternative host plants, significant variations in performance were observed, providing critical insights into host plant suitability and pest management strategies.

Our novel approach of analyzing life tables for larvae transferred at various developmental stages offers new perspectives on the adaptability and life cycle dynamics of *T. absoluta*. Future research should investigate the mechanisms underlying these host-specific differences in development and fecundity. Understanding these mechanisms could lead to the development of more effective Integrated Pest Management (IPM) strategies tailored to specific host plants, thereby improving control measures and reducing the economic impact of *T. absoluta*.

Furthermore, future studies should focus on the nutritional and chemical properties of different host plants to better elucidate the factors influencing *T. absoluta*'s adaptability and survival. By deepening our understanding of these interactions, more targeted and effective pest control strategies can be developed, ultimately minimizing infestations and optimizing crop yield and quality.

Data availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Author contributions

B.A.: Conceptualization; validation; methodology; visualization; supervision; writing original draft, editing. A.K.B.: Methodology; data curation; software. E.G.A.: Writing original draft, reviewing and communication. All authors read and approved the final manuscript.

Declarations

Competing interests

The authors declare no competing interests.

Additional information

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