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Full Length Research Paper

Biology of *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) under different temperature and relative humidity

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Tomato leaf miner, *Tuta absoluta* (Meyrick) is a pest of Solanaceae crops, particularly tomato (*Lycopersicon esculentum* (Miller)) and potato (*Solanum tuberosum* Linnaeus) in the world. There are different records on the biology of *T. absoluta* in the world mainly due to variations in temperature and relative humidity. In Ethiopia, night temperature is very low and day temperature is very high. Due to this reason, it is expected that the biology of *T. absoluta* is somehow different from what was so far recorded elsewhere. Hence, the biology of *T. absoluta* was studied at different temperatures and relative humidities under laboratory and glasshouse conditions for two consecutive seasons. In the experiment, developmental stage, adult longevity, fecundity and oviposition period were recorded. *T. absoluta* female laid about 60.56% of her egg on the upper side surface of tomato leaf, while the lowest (0.85%) was laid on tomato stem. The highest number of eggs of 233.75±14.42 was laid at 20.5±2°C and 55±5% R.H., whereas the lowest number of eggs (177.5±9.26) was laid at 32.0±2°C and 40±5% R.H. Considering the life cycle and longevity of adult *T. absoluta*, the results revealed that at 20.5±2°C (55±5% R.H.), no significant (P > 0.05) difference was observed between laboratory and glasshouse conditions in the case of complete life cycle. The life expectancy of adult was high at low temperature and low at high temperature. As temperature increased (20.5°C and above), developmental time of the moth appeared to decrease.

Key words: Biology, life span, fecundity, *Tuta absoluta,* temperature, relative humidity.

INTRODUCTION

Tomato, *Lycopersicon esculentum* (Miller) (Solanaceae), is one of the most economically important crops in Ethiopia. Various insect pests are reported to attack tomatoes worldwide (Lange and Bronson, 1981). Some of the pest species are known to be of great economic importance; among them are the tomato leaf miner, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) and tomato fruit borer, *Helicoverpa armigera* (Hubner) (Lepidoptera:

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Noctuidae), which are very serious insect pests of tomato plants.

Tomato leaf miner, *T. absoluta* (Meyrick) is a native devastating pest of South America, particularly to tomato, *L. esculentum* (Miller) (Desneux et al., 2010; Gontijo et al., 2013). It may be described as an intercontinental pest. Although *T. absoluta* is an endemic neotropical pest, it has acquired a wider geographical distribution after its unintended introduction in other tomato production regions since its first detection in Europe in late 2006 (Urbaneja et al., 2007)

Over the past decade, a substantial amount of research in South America has addressed a wide range of topics related to *T. absoluta* biology, ecology, impacts and management. Since its unintentional introduction from Mediterranean region through Sudan to Ethiopia, this invasive pest has devastated indescribable thousands hectares of tomato crop. It is considered to be one of the most important Lepidopterous pests associated with tomato, in Ethiopia (Gashawbeza and Abiy, 2013). Larvae of this insect are known to feed on the leaf mesophyll tissue expanding miners, and fruits of the crop with subsequent reduction of the yield. It has a high reproductive rate, where the female lays 260 eggs during its life (EPPO, 2005) on tomato plants. Few authors have studied the life tables of *T. absoluta* on tomato plants (Miranda et al., 1998; Pereyra and Sànchez, 2006; Aksu and Çıkman, 2014; Erdogan and Babaroglu, 2014). It has become an increasingly important pest in Ethiopia when information on its biology was discovered, even in its native range which was scarce. From the perusal of the literature, this work is the first in Ethiopia on the Ethiopian strains of *T. absoluta* reared on tomato host plant. Therefore, the objective of the present work is to study the biology and oviposition of *T. absoluta* on the tomato plants under laboratory and glasshouse conditions.

MATERIALS AND METHODS

The biology of *T. absoluta* on tomato was studied under laboratory and glass house temperature; 20.5±2°C and 55±5% R.H. in the laboratory and 32.0±2°C and 40±5% R.H. in the glasshouse. *T. absoluta* larvae were collected from the fields and brought to the laboratory and glasshouse. The tomato leaf miner larvae present on these collected tomato leaves were wrapped with wet cotton kept in plastic box (20 x 15 cm^2) in the laboratory and glasshouse. After the emergence of the adults, cages were prepared under glasshouse and laboratory. Newly emerged adults were collected from the ovipositing female of laboratory culture and placed on the tomato plant in the cages.

Adult *T. absoluta* used in this study was obtained from the culture maintained in the laboratory with temperature and relative humidity, under natural light. Ten pairs of *T. absoluta* from this stock culture were sexed and released into a rectangular box cage (1× 0.6 m). *T. absoluta* was maintained in the glasshouse. A mixture of sugar, yeast and water was placed in a Petri dish as a food supplement in the cage for adult *T. absoluta*. Everyday, temperature, relative humidity, number of eggs, larva, pupa and oviposition period per females, sex ratio and longevity of female and male were recorded both under laboratory and glasshouse conditions.

Life table construction

The number of alive and mortality of *T. absoluta* in all the stages was recorded daily. The following assumptions were used in the construction of the life-table of *T. absoluta*.

$q_x = [d_x / l_x] \times 100$

Where x = Age of the insect in days; l_x = number of survival at the beginning of each interval; d_x = number dying at age interval; q_x = mortality rate at age interval x calculated using the following formula

$e_x = T_x / l_x$

e_x = Expectation of mean life remaining for individuals of age x. Life expectation was calculated using the equation:

$L_x = l_x + 1 (x + 1)/ 2$

To obtain e_x, two other parameters L_x and T_x were also computed as follows:

L_x = The number of individuals alive between age x and x + 1 calculated by the equation.

$T_x = l_x + (l_x + 1) + (l_x + 2) \ldots\ldots + l_w$.

Where l_w = The last age interval; T_x = the total number of individual of x age units beyond the age x obtained by the equation.

Developmental stages of specific life table

Data on stage specific survival and mortality of eggs, larvae, pupae and adults of *T. absoluta* were recorded from the age specific life-table. x = Stage of *T. absoluta*; l_x= number of survival at the beginning of the stage x; d_x = Mortality during the stage indicated in the column x.

The data calculated through the above assumptions for computing various life parameters such as apparent mortality (A_m), survival fraction (S_f), mortality survivor ratio (MSR), indispensable mortality (I_M) and K-values were calculated according to Arshad and Parvez (2010).

Data analysis

All the necessary data were recorded and analyzed with calculated means of days. Data collected were subjected to analysis of variance (ANOVA) to determine the significance differences among the treatments using SAS Programme version 9.1 (SAS, 2009). Life table analyses were calculated according to Jackknife's method (Sokal and Rohlf, 1995).

RESULT AND DISCUSSION

Eggs laying positions of *T. absoluta* on tomato plants

Results showed that oviposition preferences were significantly ($P < 0.05$) different from the others. All adult female *T. absoluta* laid their eggs on the upper side of the tomato leaves (60.56%) followed by the lower side (35.21%). The lowest parts of the plant where eggs were laid are as follows: stem (0.85%), flowers (1.41%) and fruit (1.97%) (Figure 1).

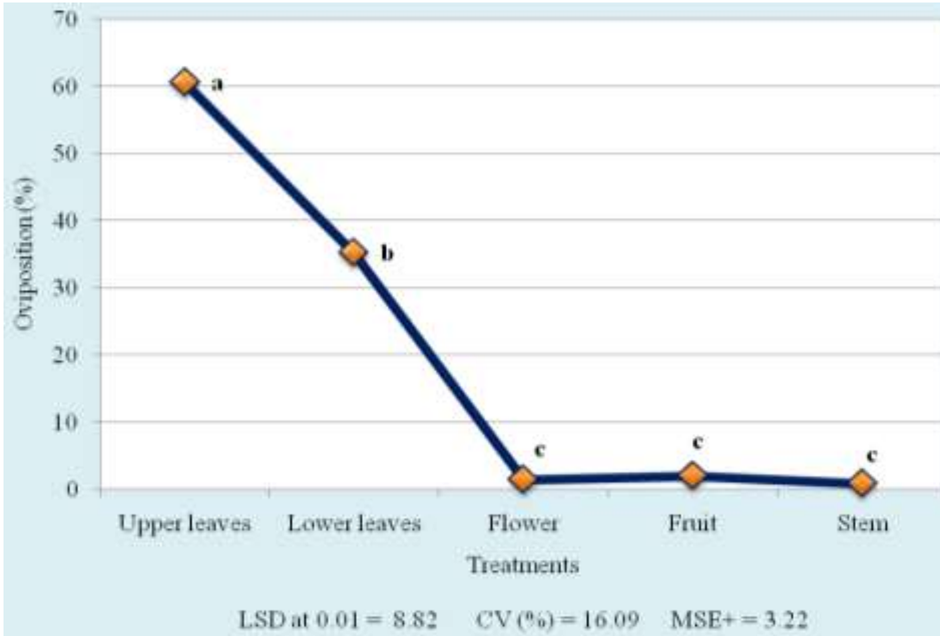

Figure 1. Egg laying position of *T. absoluta* on tomato plant under glasshouse condition.

This study result disagrees with the previous work of Torres et al. (2001). They reported that before flowering, *T. absoluta* females chose the lower side of the leaf for oviposition in the apical part of the plant canopy. But, the study agrees with Leite et al. (2004) who demonstrate that there is a preferential deposition of *T. absoluta* eggs on the upper side leaves at the apex of the tomato plant. Furthermore, Leite et al. (1999) found that *T. absoluta* oviposited more on leaves of the apical and medium portions than in the basal parts of the tomato plant. According to different authors' report, the preferential oviposition in the upper leaves was probably due to the fact that these leaves are more tender, as they have lower calcium content and percentage of insoluble leaf fibre in acid detergent compared to the middle and lower leaves (Marschner, 1995; Silva et al., 1998; Leite et al., 1999; Wei et al., 2000).

Developmental stage of *T. absoluta*

Significant ($P < 0.05$) differences were observed between laboratory and glasshouse studies on the life cycle of *T. absoluta* in both seasons. The female *T. absoluta* laid from 177.5 eggs/female at 32±2°C (40±5% R.H.) to 233.75 eggs/female at 20.5±2°C (55±5% R.H.) during her life span in 2015. Similarly, in 2016, the female *T. absoluta* laid 211.25 and 168.25 eggs at 20.5±2°C (55±5% R.H.) and 32±2°C (40±5% R.H.), respectively. Most of the eggs were embedded on the upper and lower leaf. Similar to our results, Uchoa-Fernandes et al. (1995) stated that the oviposition period was 7 days after first mating with a maximum life time fecundity of 260 eggs per female.

At an average of two consecutive seasons after 13 to 13.5 days, the eggs were hatched for the first instar larva at 20.5±2°C (55±5% R.H.), while at 32±2°C (40±5% R.H.) it took 10 to 10.5 days. The finding disagrees with the previous work of Erdogan and Babaroglu (2014), EPPO (2005) and Torrest et al. (2001) that the period of egg hatching was between 4-5 days.

A total of larval instars were observed in this study; it took 12.5 days at 20.5±2°C (55±5% R.H.) in the laboratory and 11 to 11.51 days at 32±2°C (40±5% R.H.), respectively. The results were confirmed by the work of Erdogan and Babaroglu (2014). They found that total period of larvae instar was 10.97 days; Pereyra and Sanches (2006) reported that the period of larvae instar of *T. absoluta* was 12.14 days at 25±1°C. It was also determined that the period of larvae instar of *T. absoluta* was 13-15 days (EPPO, 2005). Torrest et al. (2001) stated that the period of larvae instar of *T. absoluta* was 12 and 16 days at 27°C.

The developmental time of pupa ranged from 8.2 to 9.8 days at temperature of 20.5±2°C (55±5% R.H.) and 6.5 to 8.6 days at 32±2°C (40±5% R.H.) (Figure 2). Gadir et al. (2016) stated that the pupal development time of the tomato leafminer varied from 7.07 to 8.62 days on two tomato cultivars. It was found that the period of pupae instar of *T. absoluta* was 9.53 days (Erdogan and Babaroglu, 2014). Torres et al. (2001) also found the pupal developmental time of *T. absoluta* as 7 to 9 days. These studies are similar to the current findings.

The total mean of developmental period for *T. absoluta*

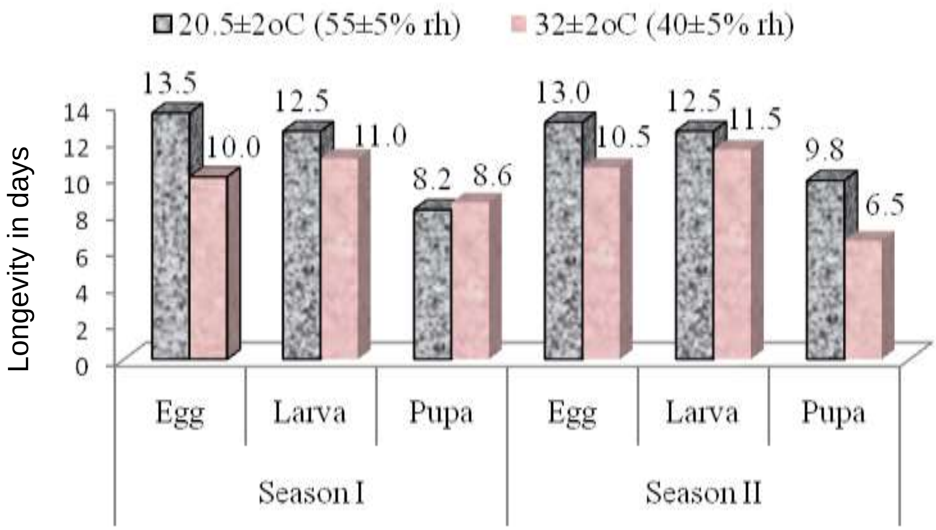

Figure 2. Mean developmental stages of *T. absoluta* at different temperature and relative humidity under laboratory and glasshouse in seasons I and II under laboratory and glasshouse conditions during 2015-2016.

Table 1. Some biological parameters of *T. absoluta* from infested tomato plants in season I (2015).

Mean temperature and r.h.	Mean number of egg laid per female	Mean Complete life cycle (days)	Mean Life expectancy (days)	
			Male	Female
20.5±2°C (55±5% r.h.)	233.75±14.42[a]	30.6±0.59[a]	9.0±0.30[a]	18.40 ±1.45[a]
32±2°C (40±5% r.h.)	177.5±9.26[b]	27.8±0.57[a]	6.8±0.27[b]	15.2±1.40[b]
LSD at 0.01	26.64	6.25	1.04	2.69
CV (%)	5.76	7.49	7.49	9.12
MSE ±	11.84	0.59	0.39	1.53

Means with the same letter(s) in rows are not significantly different from each other. All treatment effects were highly significant at p<0.01 (DMRT).

from egg to adult was 30.6 to 31.2 days at 20.5±2°C (55±5% R.H.); while at 32±2°C (40±5% R.H.), it ranged from 26.4 to 27.8 days under glasshouse conditions (Table 1 and 2). The results agreed with the findings of Erdogan and Babaroglu (2014) showing that means of developmental period from egg to adult was 30.18 days. EPPO (2005) reported that under optimal conditions, *T. absoluta* developed in about 30 days. Barrientos et al. (1998) also found that average development time of *T absoluta* was 23.8 days at 27.1°C. Cuthbertson (2011) reported that the development from egg to adult took 35 days at 25°C. He also mentioned in the same year in England under greenhouse conditions, the mean total development time of *T. absoluta* was 39.8 days at 19.7 °C. Erdoghan and Babaroglu (2014) showed that the mean total development time of *T. absoluta* was 30.18 days on tomato at 25–26°C. *T. absoluta* developed slightly faster in this study compared to the results obtained by other researchers. This might in part be attributed to the tomato cultivar differences and possible differences in the population of *T. absoluta* in these results. According to Du et al. (2004), the developmental period of the herbivore insects is strongly affected by the nutritional qualities of the host plant, which in turn influences its population growth. On the other hand, the chemical components of host plants can also affect the survival, growth and reproduction of herbivore insects (Wilson and Huffaker, 1976; Bernays and Chapman, 1994; Adebayo and Omoloyo, 2007).

Age specific developmental stages

Mortality percentage of eggs was recorded during life cycle: 1.40% at 20.5±2°C (55±5% R.H.) and 4.93% at 32±2°C (40±5% R.H.). But Cuthbertson (2011) stated that in the development stage, the survival of the egg stage was 100%; no mortality rate was recorded. The

Table 2. Some biological parameters of *T. absoluta* from infested tomato plants in season II (2016).

Mean temperature (°C)	Mean number of egg laid per female	Mean complete life cycle	Mean life span in days	
			Male	Female
20.5±2 (55±5% r.h.)	211.25±11.37[a]	31.2±1.87[a]	8.2±0.91[a]	16.0±1.04[a]
32±2 (40±5% r.h.)	168.25±9.07[b]	26.4±1.32[a]	6.2±0.68[b]	14.4±0.87[b]
LSD at 0.01	22.54	4.92	1.52	0.68
CV (%)	5.28	9.73	12.60	2.55
MSE ±	10.02	2.80	0.87	0.39

Means with the same letter in rows are not significantly different from each other. All treatment effects were highly significant at p<0.01 (DMRT).

Table 3. Mean survival percent of *T. absoluta* during the life cycle under laboratory and glasshouse temperature and relative humidity during 2015-2016.

Treatments	Mean Survival (%)			Mean mortality (%)		
	Egg	Larva	Pupa	Egg	Larva	Pupa
20.5±2 (55±5% R.H.)	95.80[a]	81.01[a]	89.77[a]	4.20	15.99	10.23
32±2 (40±5% R.H.)	83.80[b]	81.51[a]	78.26[b]	16.20	18.49	21.74
LSD	2.74	19.83	3.39			
CV (%)	0.87	6.51	1.16			
MSE ±	0.78	5.65	0.96			

Means with the same letter(s) in rows are not significantly different for each other. All treatment effects were highly significant at p<0.01 (DMRT).

highest larval mortalities (26.49%) were recorded at 30.5±2°C (40±5% R.H.), while the lowest mortalities (15.99%) were at 20.5±2°C (55±5% R.H.) under glasshouse and laboratory, respectively. The pupal mortality rates during the study periods were recorded as 10.23 and 32.42% under laboratory and glasshouse conditions, respectively. Erdogan and Babaroglu (2014) found that the survival rate of pupa was 63.10% that is, 36.9% mortality. It was very high compared to that of this result (Table 3). From these studies, it is understood that at high temperature, the mortality percentages of all stages increased during developmental periods of *T. absoluta* under both conditions.

Significant (P < 0.05) differences between treatments of survival percent of eggs were recorded during their life cycle from eggs to larval stage. 143 eggs were hatched. Among these, 137 eggs emerged to first instar larvae (95.8%) and 6 eggs died due to unknown reasons. There were no significant (P > 0.05) differences between treatments, regarding larval survival in both conditions. Among 137 larvae hatched, 124 emerged to pupae (81.01%) and also, from the hatched pupae, only 109 emerged to adults (89.77) at 20.5±2°C (55±5% R.H.). On the other hand, at the same time, 142 eggs were collected and hatched under glasshouse, at 32±2°C (40±5% R.H.). Among the hatched eggs, 119 emerged to larvae (83.80%). From the 119 hatched larvae, 92 emerged to pupae (81.51%). Finally, among the hatched pupae, 72 adults of *T. absoluta* emerged to adults (78.26%) during 2015-2016 (Table 3).

Apparent mortality (A_M)

Maximum apparent mortality was observed in fourth instar larvae (11.68%), while minimum mortality was recorded in second instar larvae (0.72) at 20.5±2°C (55±5% R.H.). Also, maximum apparent mortality was observed in last pupal stage (2.17%) while minimum mortality was recorded in third instar larvae (1.65%) at 32±2°C (40±5% R.H.), from 2015-2016. When a comparison was made between larval instars, the highest mortality (11.68%) was observed at fourth instar, whereas, minimum mortality was recorded at second instar (0.72) at 20.5±2°C. Similarly, mortality at pre pupa and pupal stages remained minimum (7.03 and 3.23%) at 20.5±2°C, respectively. In a similar way, at 32±2°C (40±5% R.H.), maximum mortality was recorded as 10.68% while minimum mortality was 2.17%, respectively (Table 4 and 5). In the present findings, the early pre - pupae were higher than the later pupa, and hence, showed higher mortality at pre -pupae stage, which was observed at 20.5±2°C (55±5% R.H.). However, in glasshouse experiment at 32±2°C (40±5% R.H.), the

Table 4. Stage specific life table of *T. absoluta* on tomato plant at 20.5±2°C (55±5% R.H.) during 2015-2016.

Stage x	No. surviving at the beginning of the stage l_x	No. dying in each stage d_x	Apparent mortality $143q_x$	Survival fraction S_x	Mortality survivor ratio (MSR)	Indispensable mortality I_M	log l_x	K-values
Egg	143	2	1.40	0.99	0.014	1.53	2.1553	0.0061
First instar	141	2	1.42	0.99	0.013	1.42	2.1492	0.0062
Second instar	139	1	0.72	0.99	0.007	0.76	2.1430	0.0033
Third instar	138	1	2.17	0.99	0.007	0.76	2.1397	0.0030
Fourth instar	137	16	11.68	0.93	0.117	12.75	2.1367	0.0295
Pre pupa	128	9	7.03	0.97	0.070	7.63	2.1072	0.0137
Pupa	124	4	3.23	0.88	0.032	3.49	2.0935	0.0560
Adult	109	-	-	-	-	-	2.0375	-
								K=0.1178

Table 5. Stage specific life table of *T. absoluta* on tomato plant at 32±2°C (40±5% R.H.) during 2015-2016.

Stage x	No. that survived at the beginning of the stage l_x	No. that died in each stage d_x	Apparent mortality $100q_x$	Survival fraction S_x	Mortality survivor ratio (MSR)	Indispensable mortality I_M	log lx	K-values
Egg	142	7	4.93	0.95	0.05	3.60	2.1523	0.0487
First instar	135	9	6.67	0.94	0.07	5.04	2.1305	0.0269
Second instar	127	6	4.72	0.95	0.05	3.60	2.1036	0.0208
Third instar	121	2	1.65	0.98	0.02	1.44	2.0828	0.0073
Fourth instar	119	16	13.45	0.87	0.13	9.36	2.0755	0.0629
Pre pupa	103	11	10.68	0.89	0.11	7.92	2.0126	0.0623
Pupa	92	20	21.74	0.78	0.23	16.56	1.9637	0.1062
Adult	72	-	-	-	-	-	1.8575	-
								K= 0.3980

highest mortality of *T. absoluta* was observed at last pupal stage.

Survival fraction (S_x)

In Tables 4 and 5, the maximum survival fraction was 0.99, from egg stage to third instar larvae at 20.5±2°Cand the minimum survival fraction was 0.88 at 30±2°C. Among larval instars, the S_x was very high at 0.99, but it was very minimum (0.88) during pupal stage at 20.5±2°C (55±5% R.H.). On the other hand, at 32±2°C (40±5% R.H.), maximum S_x (0.98) was obtained, but it was very minimum at pupal stage (0.78). Similarly, in another experiment, much lower survival of *T. absoluta* was obtained from 20 to 23°C (Miranda et al., 1998).

Mortality survivor ratio (MSR)

Mortality survival ratio (MSR) at egg stage was minimum (0.014) at 20.5±2°C (55±5% R.H.) and maximum (0.05) at 32±2°C (40±5% R.H.). Mortality survival ratio of larval instar at 20.5±2°C (55±5%) indicated that 0.007 was found at second and third instar larvae and 0.117 was found at fourth instar larvae. While at 32±2°C (40±5% R.H.), minimum larval instar was 0.02 at third instar larvae and 0.13 at fourth instar larvae. Between the pre- pupa and pupa, maximum mortality survival ratio (0.23) was observed at pre- pupa and minimum mortality survival ratio (0.11) was observed at 20.5±2°C (55±5%).

On the other hand, minimum (0.032) ratio was obtained at last pupal stage and 0.07 at pre- pupal stage at 32±2°C (40±5% R.H.). In the current study, *T. absoluta* showed high natural mortality during its life cycle at larval stage and pupa knownto be the most critical. Therefore, the findings on the mortality performance of *T. absoluta* corroborate with the study of Miranda et al. (1998).

Indispensable mortality (I_M)

Indispensable mortality at egg stage was observed to be maximum (12.75) at fourth larval instar and the minimum results were recorded (0.76) at second and third larval instars at 20.5±2°C (55±5% R.H.). While comparing indispensable mortality between pupal stages, the maximum result (7.63) and minimum (3.49) at maximum (7.83) was observed to be similar in temperature and relative humidity. At 32±2°C (40±5% R.H.), the lowest value (1.44) was recorded at third instar and the maximum value was observed (16.56) at pupal stage (Tables 4 and 5).

K-values

The k-value was found to be minimum (0.0061) and maximum (0.0487) at 20.5±2 (55±5% R.H.) and 32±2°C (40±5% R.H.) during egg stage, respectively. While comparing larval instars, there was maximum 'k' (0.0295) at fourth instar and lowest 'k' (0.0030) at third instar larvae at 20.5±2°C (55±5% R.H.). In the case of pupal stage in both conditions, the highest k-value was recorded at last pupal stage (Tables 4 and 5). The total generation mortality k-value was recorded as maximum (0.3980) at 32±2°C (40±5% R.H.) and minimum (0.1178) at 20.5±2°C (55±5% R.H.). Similar findings were obtained for Mediterranean fruit fly (Carey, 1982).

Adult longevity of *T. absoluta*

Results from the study revealed that there was a significant ($P < 0.05$) difference in longevity of *T. absoluta* in all the treatments. There was no significant ($P > 0.05$) difference in longevity when female *T. absoluta* lived (17.2) at mean temperature and relative humidity of 20.5±2°C (55±5% R.H.), while the male *T. absoluta* lived for 8.9 days with an average of two seasons. On the other hand, at temperature and relative humidity of 32±2°C (40±5% R.H.) in the glasshouse, male and female *T. absoluta* lived for 6.5 and 14.8 days, respectively. In this temperature range, the life cycle of male and female *T. absoluta* is shorter compared to the other temperatures (Tables 1 and 2). The findings are close to the previous studies of Estay (2000), that observe that adult *T. absoluta* lifespan ranged between 10 and 15 days for females and 6 -7 days for males. It was found that adult longevity for male and female individuals was 15.8 and 18.16 days, respectively (Erdogan and Babaroglu, 2014).

The results are similar to those reported by Torrest et al. (2001) that the developmental period of larval instar of *T. absoluta* was 12–16 days at 27°C. The findings at 20.5±2°C (55±5% R.H.) showed that in both seasons, 13 to 13.5 days at 32±2°C (40±5% R.H.) were shorter than an average of 11 to 11.5 days. This study is in agreement with the findings of Pereyra and Sanches (2006) that the period of larvae instar of *T. absoluta* was 12.14 days at 25±1°C. It is resolute that the developmental period of larvae of *T. absoluta* was 13 to 15 days (EPPO, 2005). The two seasons results of pupal developmental stages revealed that it took 8.2 to 9 days at 20.5±2°C (55±5% R.H.) and 6.5 to 8.6 days at 32±2°C (40±5% R.H.). EPPO (2005) found that the period of pupae of *T. absoluta* was an average of 9.53 days. The means of development period from egg to adult was 30.18 days. But the findings showed that at 20.5±2°C (55±5% R.H.), it was 30.6 to 31.2 days and at 32±2°C (40±5% R.H.), it was 26.4 - 27.8 days. EPPO (2005) also reported that under optimal conditions, *T. absoluta* developed in about 30 days. We also agreed with Barrientos et al. (1998) that average development time of *T. absoluta* was 23.8 days at 27.1°C. Similar results were found by Fernandez and Montagne (1990). They reported that females lived longer than males, allowing them to be sexually mature when the males emerge.

Sex ratio

One hundred eggs were collected and hatched to determine male to female sex ratio under both laboratory and glasshouse conditions. Among the hatched eggs, 48 males and 32 females emerged at 20.5±2°C (55±5% R.H.) in the laboratory, while the same number of eggs was hatched at 32±2°C (40±5% R.H.) in the glasshouse. Among these, 40 male and 36 female adults emerged from pupae. The total survival of *T. absoluta* adults in the laboratory was 80%; 3:2 male to female sex ratio. Although in the glasshouse the total survival of adults was less than those in the laboratory, it was shown that 76% adults survived in 40 male and 36 female (10:9) ratio recorded. In this finding, it was stated that usually, males were more than female individuals. The result confirmed the work of Cuthbertson (2011), which showed that males were more than females.

Conclusion

Based on these findings, it can be concluded that in different parts of tomato plant in their respective preference ranges, *T. absoluta* preferentially lays more eggs on leaves of tomato. On the other hand, *T. absoluta* at 32±2°C (40±5% R.H.) could maintain less a colony in a glasshouse than when reared at 20.5±2°C (55±5% R.H.) under laboratory condition. It has been proved as the most suitable for superior development, maximum survival and minimum mortality of *T. absoluta*. The current research paves way for provision of awareness to the farmers. Therefore, management strategies of *T. absoluta* need high attention in Ethiopian climate conditions.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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