

Original Research Article

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Biology and Morphometrics of Tomato Pinworm, *Tuta absoluta* (Meyrick) on Tomato

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ABSTRACT

Studies on the biology and morphometrics of tomato pinworm, *Tuta absoluta* (Meyrick) were conducted at mean temperature ($25\pm 2^\circ\text{C}$) and relative humidity ($75\pm 2\%$) in Insectary, Department of Entomology, S.V. Agricultural College, Tirupati on tomato hybrid Sweakar-448. The development period of *T. absoluta* had four stages viz., egg, larva, pupa and adult. The duration of egg, first, second, third and fourth instar larvae was $4.14 + 0.35$, $2.08 + 0.28$, $2.75 + 0.65$, $3.56 + 0.56$ and $3.86 + 0.64$ days, respectively. The average length and breadth of egg, first, second, third and fourth instar larvae were $0.48 + 0.05$ and $0.27 + 0.07$ mm, $1.51 + 0.07$ and $0.19 + 0.02$ mm, $2.66 + 0.04$ and $0.39 + 0.12$ mm, $4.22 + 0.06$ and $0.64 + 0.03$ mm and $7.59 + 0.09$ and $1.15 + 0.04$ mm, respectively. The total larval period of *T. absoluta* ranged from 10 to 14 days with a mean of $12.25 + 2.13$ days. The pupal period lasted for 6 to 9 days with a mean of $7.81 + 0.75$ days and length and breadth were $4.13 + 0.24$ and $1.06 + 0.14$ mm, respectively. Adult longevity on an average was $7.45 + 1.32$ days in case of males whereas $14.75 + 1.16$ days in case of females. The mean length and breadth of adults were $10.71 + 0.29$ and $1.69 + 0.10$ mm, respectively. The total development period of *T. absoluta* ranged from 22 to 27 days with a mean of $24.19 + 1.37$ days. The fecundity of *T. absoluta* ranged from 143 to 218 with a mean of $170.70 + 19.60$. The pre- oviposition, oviposition and post-oviposition periods of the female were ranged from 1 to 2, 4 to 8 and 2 to 4 days with a mean of $1.60 + 0.50$, $6.20 + 1.51$ and $2.55 + 0.60$ days, respectively. The hatching per cent of *T. absoluta* eggs ranged from 78.10 to 91.60 with a mean of $86.15 + 3.48$.

Keywords

Tomato pinworm, *Tuta absoluta*, Biology, Morphometrics

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Introduction

Tomato (*Solanum lycopersicum* L.) is one of the most widely cultivated and consumed food

crops among the vegetables in India. It is consumed as fresh table tomato and as an essential raw material for a variety of food processing industries. Tomato is rich in

minerals, vitamins and antioxidants that are important to a well-balanced diet. It is also an important dietary component because it contains high levels of lycopene, an antioxidant that reduces the risk associated with several cancers and neurodegenerative diseases. It is used as a salad, paste, peeled tomatoes, diced products, juice, sauces and soups. In India, it is cultivated in an area of 808.54 thousand ha with a production of 19696.92 thousand MT and productivity of 24.36 tonnes ha⁻¹ whereas in Andhra Pradesh, it is cultivated in an area of 55.50 thousand ha with a production of 2100.95 thousand MT and productivity of 37.86 tonnes ha⁻¹ during 2016-17 (www.indiastat.com). The major tomato producing states in India are Andhra Pradesh, Karnataka, Orissa, Maharashtra, Madhya Pradesh, West Bengal, Bihar, Gujarat, Uttar Pradesh, Himachal Pradesh, Chhattisgarh, Tamil Nadu, Telangana and Jharkhand. In Andhra Pradesh, the major tomato producing districts are Chittoor, Kadapa, Ananthapuramu, Kurnool, Prakasam and Visakhapatnam.

Tomato production has been fluctuating many biotic and abiotic constraints. Prominent among biotic constraints are pests and diseases which reduce yields and the quality of marketable fruits. Recently, South American tomato leaf miner or pinworm, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae), is emerging as major pest and causing extensive damage up to cent per cent yield loss in India particularly under South Indian field conditions. It has been reported from different parts of India throughout the year though the incidence level varies (Sridhar *et al.*, 2014).

In India, *T. absoluta* was first reported during October, 2014 infesting tomato fields in Pune, Ahmednagar, Dhule, Jalgaon, Nashik and Satara districts of Maharashtra (Shashank *et al.*, 2015). Subsequently, pest was recorded from Karnataka (Sridhar *et al.*, 2014,

Kalleshwaraswamy *et al.*, 2015 and Ballal *et al.*, 2016), Tamil Nadu (Shanmugam *et al.*, 2016 and Ballal *et al.*, 2016), Andhra Pradesh and Telangana (Anitha *et al.*, 2015), New Delhi (Shashank *et al.*, 2016), Gujarat (Ballal *et al.*, 2016), Madhya Pradesh (Swathi *et al.*, 2017), Punjab (Sandeep *et al.*, 2017), Meghalaya (Sankarganesh *et al.*, 2017) and Himachal Pradesh (Sharma and Gavkare, 2017) causing severe damage to tomato in invaded areas in India.

T. absoluta attacks the tomato crop from seedling to harvesting stage. Tomato plants are damaged by feeding on leaves, stems, flower buds and both green and ripe fruits by the invasion of secondary pathogens which enters through the wounds caused by the pest (Shashank *et al.*, 2015). In early infestation, newly emerged neonates penetrate the leaf into the mesophyll layer and feed between the lower and upper surfaces of the leaf to form small and transparent mines. As a result of continuous feeding by the larvae, the irregular mines combine together and eventually form galleries. The mines were filled with black coloured fecal pellets and over time the mined areas turns brown and dry up. In fruits, the larvae tunnel inside and leave only a pin hole visible from outside and make mines just below the surface. More than one hole are seen near to the calyx on fruit. It causes reduction in yield and fruit quality, known to cause 50 to 100 per cent loss under greenhouse and open field conditions.

T. absoluta is a microlepidopteran moth with high reproductive potential. The pest is multivoltine having nearly 10 to 12 generations per year. Females lay eggs singly on the upper and lower surface of the leaf, buds and calyxes of the green fruits. A single female can lay a total of about 260 eggs during its lifetime. Larvae in the initial instars were cream colored, later changes from greenish (second instar) to light pink (fourth

instar). Larval period is most damaging period which completed within 12 to 15 days (Estay, 2000). Pupation may take place in the soil, on the leaf surface or within the mines, depending on the environmental conditions. Adults are nocturnal and usually hide during the day between leaves. The biological cycle of *T. absoluta* is completed in 29 to 38 days, depending on the environmental conditions. The most important identifying characters are the filiform antennae, silvery-grey scales and characteristic black spots present in anterior wing (Simala *et al.*, 2011). It is a new devastating pest of tomato in India and in Andhra Pradesh, studies on biology of this pest is lacking. Knowledge on biology of this pest is necessary in designing an effective pest management strategy. Keeping the importance of *T. absoluta* in view, its biology was studied under laboratory conditions.

Materials and Methods

Biology of *T. absoluta* was studied on tomato hybrid (Sweakar-448) under laboratory conditions at mean temperature ($25\pm 2^{\circ}\text{C}$) and relative humidity ($75\pm 2\%$) in Insectary, Department of Entomology, S.V. Agricultural College, Tirupati.

Mass multiplication of *T. absoluta* under laboratory conditions

A laboratory population was established with field collected larvae and pupae from tomato growing regions in Chittoor district of Andhra Pradesh which served as the initial culture. This culture was kept in rearing cages (30x30x30 cm) in which tomato seedlings and foliage were placed as a source of food. When the leaves were fully mined fresh tomato leaves were provided to the larvae until pupation. After pupation, the pupae were kept in plastic jars for adult emergence. The newly emerged moths were enclosed in separate cages for mating. Twenty days old tomato

seedlings were provided for oviposition. Fresh seedlings were provided for every 24 hrs until the completion of oviposition by the female adults. The cotton wads soaked in honey (0.5%) fortified with vitamin E were provided as food for the moths. The plant parts containing the freshly laid eggs were removed daily and kept for hatching. Newly hatched larvae were transferred to tomato leaves.

Daily fresh leaves were provided until pupation. Rearing was continued till the emergence of the adults. This culture was used for studying the biology of the *T. absoluta*.

Biology of *T. absoluta* under laboratory conditions

To study the biology of *T. absoluta* one pair (male and female) were released on to twenty days old tomato seedlings (Sweakar-448) kept in separate cages for oviposition. Twenty four hours after release, the seedlings with fresh eggs were taken and observed under trinocular stereo zoom microscope. Then freshly laid thirty eggs were placed into petri plates (9 cm diameter). Each egg was placed in a separate petri plate. Eggs were examined daily for hatching. Fresh foliage was provided for newly emerged larvae and observed daily through pupation and adult emergence. Individual insects were observed daily for their development and survival. Observations on hatching rate (%), egg, larval, pupal period, adult longevity and total life cycle were recorded (Nayana and Kalleshwaraswamy, 2015). Only individuals that survived to the adult stage were included in the analysis. This experiment was replicated twice. Fecundity, pre-oviposition, oviposition and post-oviposition periods were also recorded. Egg, larval instars, pupae and adults were observed by using stereo zoom trinocular microscope with Dewinter Calipers Pro Version 4.6 software at Department of Entomology, S.V. Agricultural College, Tirupati.

Incubation period

Egg period was recorded as the duration of time taken from egg laying to hatching which was recognized by hatching of the larva through the egg chorion.

Larval period

The duration of larval period was recorded as the number of days taken from hatching of egg to the pupation of last instar larva.

To determine the number of larval instars and the duration of each instar, leaves with eggs laid on the same day were segregated and placed in petri plates (9 cm diameter).

From these, leaves with the eggs hatching on the same day were separated and pooled.

Each day leaves were carefully dissected and the stage (instar) of larva present inside the leaf mine was determined based on the width of head capsule. The process was continued till pupal stages.

Pupal period

Pupal period was recorded from the formation of pupa till the emergence of adult.

Total development period

Total development period from egg to adult was computed by counting the data obtained from observations and the data regarding duration of various stages of the pest were presented.

Adult longevity

The life span of adults was recorded by enclosing twenty male and twenty female adults in separate test tubes with 10 per cent honey solution.

Pre-oviposition, oviposition and post-oviposition periods

Twenty pairs (one male and one female) were taken and kept separately in different cages along with the tomato seedlings to know the pre-oviposition, oviposition and post oviposition periods.

Fecundity

Fecundity was recorded for twenty females by counting the number of eggs laid during the oviposition period for each female.

Hatching rate (%)

Number of eggs hatched out of total number of eggs was recorded at regular intervals during the oviposition period.

Morphometrics of *T. absoluta*

Morphometrics of egg, larva (each instar), pupa, adult and head capsule were measured by using stereo zoom trinocular microscope with Dewinter Calipers Pro Version 4.6 software at Department of Entomology, S.V. Agricultural College, Tirupati and expressed in millimetres (mm).

Results and Discussion

The biology and morphometrics of *T. absoluta* on tomato (Sweakar-448) was studied under laboratory conditions at mean temperature ($25\pm 2^\circ\text{C}$) and relative humidity ($75\pm 2\%$) in Insectary, Department of Entomology, S.V. Agricultural College, Tirupati. The results are presented in Tables 1 to 4. The life cycle of *T. absoluta* consists of four developmental stages viz., egg, larva, pupa and adult. Eggs laid singly on the upper and lower surfaces of the leaves, buds, stems and calyx. A brief description of each development stage is illustrated hereunder.

Incubation period

Eggs were small, oval or oblong, microscopic, creamy white in colour when laid and later turned to yellow and finally to black before hatching. Incubation period ranged from 4 to 5 days with a mean of 4.14 ± 0.35 days (Table 1). The present results are comparable with the findings of Erdogan and Babaroglu (2014) and Manoj *et al.*, (2017) who reported the egg period of *T. absoluta* as 4.10 days and 4.08 ± 0.55 days, respectively. Similarly, Nayana and Kalleshwaraswamy (2015) and Sridhar *et al.*, (2015) also reported that the incubation period of *T. absoluta* lasted for 3.90 ± 0.91 and 3.75 ± 1.11 days, respectively. The mean length and breadth of eggs were 0.48 ± 0.05 and 0.27 ± 0.07 mm, respectively (Table 3).

Larva

During the present study, larva undergone three moults and four larval instars were recorded. Based on width of the head capsule and exuviae in each moulting the instars were recognised.

First instar larva

First instar larva was white or cream colour with prominent black head. It was very sensitive and immediately after hatching mined within the leaves. The duration of first instar larva was 2-3 days with a mean of 2.08 ± 0.28 days (Table 1). The mean length and breadth of first instar larva was 1.51 ± 0.07 and 0.19 ± 0.02 mm, respectively (Table 3).

The head capsule width of first instar larva ranged from 0.16 to 0.22 mm with a mean of 0.18 ± 0.02 mm (Table 4).

Second instar larva

Second instar larva was cream colour with black head. The duration of second instar larva ranged from 2 to 4 days with a mean of $2.75 \pm$

0.65 days (Table 1). The mean length and breadth of second instar larva were 2.66 ± 0.04 and 0.39 ± 0.12 mm, respectively (Table 3). The head capsule width of second instar larva ranged from 0.24 to 0.35 mm with a mean of 0.30 ± 0.03 mm (Table 4).

Third instar larva

Third instar larva was greenish in colour with dark brown head. At this instar the larva was more active, fed more and size increased gradually than the first and second instars. The duration of third instar larva ranged from 3 to 5 days with a mean of 3.56 ± 0.56 days (Table 1). The mean length and breadth of third instar larva was 4.22 ± 0.06 and 0.64 ± 0.03 mm, respectively (Table 3). The head capsule width of third instar larva ranged from 0.35 to 0.45 mm with a mean of 0.38 ± 0.03 mm (Table 4).

Fourth instar larva

Fourth instar larva was greenish to pink colour with dark brown head. At this instar the larva fed more voraciously. It was easily recognised by the presence of pinkish bands on dorsal surface of larva. The duration of fourth instar larva ranged from 3 to 5 days with a mean of 3.86 ± 0.64 days (Table 1). The mean length and breadth of fourth instar larva was 7.59 ± 0.09 and 1.15 ± 0.04 mm, respectively (Table 3). The head capsule width of fourth instar larva ranged from 0.53 to 0.63 mm with a mean of 0.58 ± 0.04 mm (Table 4).

The total larval period of *T. absoluta* ranged from 10 to 14 days with a mean of 12.25 ± 2.13 days (Table 1). These results are close in agreement with the findings of Nayana and Kalleshwaraswamy (2015) and Pereyra and Sanchez (2006) who reported that, the larval period of *T. absoluta* was 11.80 ± 1.25 and 12.14 days, respectively. Similarly, Shehata *et al.*, (2016) also recorded *T. absoluta* larval duration as 11.7 ± 0.47 days.

Table.1 Duration of different development stages of *T. absoluta* on tomato

Stage of the pest	Development period (Days)
	Mean \pm SD
Egg	4.14 \pm 0.35
Larva	
1 st instar	2.08 \pm 0.28
2 nd instar	2.75 \pm 0.65
3 rd instar	3.56 \pm 0.56
4 th instar	3.86 \pm 0.64
Total larval period	12.25 \pm 2.13
Pupa	7.81 \pm 0.75
Total development period	24.19 \pm 1.37

Table.2 Pre-oviposition period, oviposition period, post oviposition period, fecundity, hatching (%), adult longevity of male and female of *T. absoluta* on tomato

Parameter	Mean \pm SD
Pre-oviposition period (Days)	1.60 \pm 0.50
Oviposition period (Days)	6.20 \pm 1.51
Post-oviposition period (Days)	2.55 \pm 0.60
Fecundity	170.70 \pm 19.60
Hatching (%)	86.15 \pm 3.48
Male adult longevity (Days)	7.45 \pm 1.32
Female adult longevity (Days)	14.75 \pm 1.16

Table.3 Morphometric dimensions of different development stages of *T. absoluta* on tomato

Development Stage	Mean \pm SD	
	Length (mm)	Breadth (mm)
Egg	0.48 \pm 0.05	0.27 \pm 0.07
Larva		
1 st instar	1.51 \pm 0.07	0.19 \pm 0.02
2 nd instar	2.66 \pm 0.04	0.39 \pm 0.12
3 rd instar	4.22 \pm 0.06	0.64 \pm 0.03
4 th instar	7.59 \pm 0.09	1.15 \pm 0.04
Pupa	4.13 \pm 0.24	1.06 \pm 0.14
Adult	10.71 \pm 0.29	1.69 \pm 0.10

Table.4 Head capsule width of different larval stages of *T. absoluta* on tomato

Host	Head capsule width (mm)			
	I instar	II instar	III instar	IV instar
Tomato	0.18 \pm 0.02	0.30 \pm 0.03	0.38 \pm 0.03	0.58 \pm 0.04

Polat *et al.*, (2016) who reported that the larval period as 12.82 to 26.7 days. Torres *et al.*, (2001) observed that larval period of *T. absoluta* as 12 to 16 days at 27°C.

Pupal period

The pupa was greenish yellow initially and later turned to brown. Pupation took in folded leaves or filter paper in laboratory. Male and female pupa was differentiated based on the size. Female pupa was larger than the male. Wing case is nearer to posterior abdominal segment in case of males whereas in females it is away to posterior abdominal segment. Pupal period ranged from 6 to 9 days with a mean of $7.81 + 0.75$ days (Table 1). The present results are in close agreement with the findings of Torres *et al.*, (2001) who reported pupal period of *T. absoluta* lasts for 7 to 9 days at 27°C. Similar results were obtained by Bajracharya and Bhat (2018) who recorded the average pupal period of *T. absoluta* as 7.11 days. Ballal *et al.*, (2016) and Polat *et al.*, (2016) also reported the pupal period of *T. absoluta* lasts for 10 and 7.52 to 20.62 days, respectively. The mean length and breadth of pupa was $4.13 + 0.24$ and $1.06 + 0.14$ mm, respectively (Table 3).

Total development period

The total development period of *T. absoluta* ranged from 22 to 27 days with a mean of $24.19 + 1.37$ days on tomato (Table 1). The results of present investigations are supported with the findings of Ballal *et al.*, (2016) who reported that *T. absoluta* life cycle was 21 to 23 days on tomato. Similar results were also reported by Barrientos *et al.*, (1998) and Desneux *et al.*, (2010) who recorded the duration of the life cycle of *T. absoluta* on tomato as 20 to 27 and 26 to 31 days, respectively. Head capsule size and instar statistics are necessary to understand basic phenomena associated with larval stage of

insect. The effect of any insecticide varies according to instar. This fundamental entomological information is important for proper timing of insecticides application as it depends upon the dominance of particular larval stage in field conditions. Instar information is also necessary in proper application of entomopathogens for effective management of insect pest. These findings on biology and morphometrics will help in understanding the development of *T. absoluta* and formulation of effective management strategy against it.

Adult longevity

Adult moths were small, nocturnal, brown to silver scales with black spots on the forewings. The antennae are filiform and the wings are fringed. Males are slightly darker and smaller than females. Females are light in colour and larger than males. The abdomen of the female moths is wider compared to narrower and pointed abdomen of males. The longevity of the male ranged from 5 to 9 days with a mean of $7.45 + 1.32$ days where as female longevity ranged from 12 to 16 days with a mean of $14.75 + 1.16$ days (Table 2). Longevity of the females was more than males. Manoj *et al.*, (2017) reported 7.50 ± 1.20 days as longevity of adult male and 15.01 ± 1.47 days for female, which was similar to present findings. In contrary to present findings, Polat *et al.*, (2016) reported that the longevity of males and females were 3.37 to 6.14 and 7.7 to 9.75 days, respectively. The mean length and breadth of adults were $10.71 + 0.29$ and $1.69 + 0.10$ mm, respectively.

Fecundity

The number of eggs laid per female ranged from 143 to 218 with a mean of $170.70 + 19.60$ on tomato (Table 2). The present results are comparable with the findings of Manoj *et*

al., (2017) who reported that the fecundity varied from 165.05 ± 6.22 eggs per female. Similarly, Salama *et al.*, (2014) also recorded the fecundity of *T. absoluta* varied from 162 ± 30.94 eggs per female.

Pre-oviposition, oviposition and post-oviposition periods

The pre- oviposition, oviposition and post-oviposition periods of the female were ranged from 1 to 2, 4 to 8 and 2 to 4 days with a mean of $1.60 + 0.50$, $6.20 + 1.51$ and $2.55 + 0.60$ days, respectively (Table 2). The results of present finding are in close agreement with the findings of Erdogan and Babaroglu (2014) who reported that the pre oviposition, oviposition periods were 1.28 and 7.88 days, respectively.

Hatching rate (%)

The hatching per cent of *T. absoluta* eggs ranged from 78.10 to 91.60 with a mean of $86.15 + 3.48$ (Table 2).

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