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Lakshmi Sireesha ET
Department of Entomology, S.V. Agricultural College, ANGRAU, Tirupati, Andhra Pradesh, India

Ramesh Babu T
Department of Entomology, S.V. Agricultural College, ANGRAU, Tirupati, Andhra Pradesh, India

Koteswara Rao SR
Department of Entomology, S.V. Agricultural College, ANGRAU, Tirupati, Andhra Pradesh, India

Corresponding Author:
Lakshmi Sireesha ET
Department of Entomology, S.V. Agricultural College, ANGRAU, Tirupati, Andhra Pradesh, India

Biology of tomato pinworm, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) on different host plants

Lakshmi Sireesha ET, Ramesh Babu T and Koteswara Rao SR

Abstract
South American tomato pinworm, *Tuta absoluta* **(**Meyrick) is the emerging invasive pest on tomato and other crops in India. Biology of *T. absoluta* was carried out on three solanaceous hosts *viz.*, tomato, potato and brinjal. Tomato was the most preferred host followed by potato and brinjal for its development. Number of eggs laid per female was significantly more in tomato (151.31 eggs) followed by potato (57.26 eggs) and brinjal (34.5 eggs), respectively. Similarly, egg hatching was fastest in tomato (4.57days) followed by potato (4.91days) and brinjal (6.12 days). The four instars duration of *T. absoluta* on tomato (2.31, 2.29, 3.28, 3.26), potato (2.92, 2.90, 4.07, 4.26) and brinjal (3.02, 3.45, 4.64, 5.59) was recorded. Survival rate of both sexes was more on tomato (Males 59.26 days and Females 40.73 days) than on potato (55.95 and 44.04 days) and brinjal (62.16 and 37.83 days). So, it is concluded that *T. absoluta* completed the life cycle faster on tomato and the fecundity was also higher on tomato. Hence, it can be ascribed that tomato has been the preferred host compared to potato and brinjal.

Keywords: Adult longevity, biology, host plants, invasive pest, *T. absoluta*

1. Introduction
South American tomato pinworm, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) is an invasive pest associated with solanaceous crops. Tomato is the primary host of *T. absoluta*, but it has been reported on other secondary hosts like potato (*Solanum tuberosum* L.), egg plant (*Solanum melongena* L.), pepper (*Capsicum annuum*), sweet pepper (*S. muricatum* L.) and tobacco (*Nicotiana tabacum* L.) (Campos, 1976; Pereyra and Sanchez, 2006) [3, 11] and other solanaceous weeds, including *Datura stramonium* L., *D. ferox* L., and *N. glauca* (Larrain, 1986) [7]. In India, *T. absoluta* was first reported by Sridhar *et al.*, (2014) [12] and recently spreading rapidly in southern states of the country (Anitha Kumari *et al.*, 2015; Kalleshwaraswamy *et al.*, 2015; Shashank *et al.*, 2015) [2, 6, 13]. *T. absoluta* causes reduction in yield and fruit quality causing up to 100% loss in both greenhouses and open field conditions (Sridhar *et al.*, 2014; NAPPO, 2012) [12, 10]. Different parts of tomato plants like leaves, stems, buds, calyces, young and ripe fruits are damaged by feeding of *T. absoluta.* Though information on biology of *T. absoluta* is well known on tomato, there is no information on the biology of this pest on other hosts like potato and brinjal. Hence, the present study is planned to study the biology of *T. absoluta* on three solanaceous hosts *i.e.*, tomato, potato and brinjal.

2. Material and methods
Mass multiplication of tomato pinworm, T. absoluta under laboratory conditions
The initial culture of *T. absoluta* was collected from the infested fields of tomato and transferred to plastic jars containing tomato leaves as a food source. The fresh and healthy tomato leaves were provided to the developing larvae of *T. absoluta* as and when required till the larvae moults into pupa. The pupae were collected and transferred to oviposition cages (30×30×30 cm) and the newly emerged adults were provided with 10 per cent honey solution containing vitamin E as a food source. Equal number of males and females were confined to the oviposition cages provided with tomato seedlings as oviposition substrate. The eggs laid by adults on tomato seedlings were collected daily and kept for egg hatching. After hatching, fresh tomato leaves were provided for newly emerged neonate larvae until pupation. Pupae were collected and transferred to adult rearing cages provided with adult food. This process was repeated continuously and the culture was maintained under laboratory conditions at 25 ±

20^0C and 75 ± 2 per cent RH throughout the experiment for further studies. Similarly, the culture was also maintained in net house conditions.

Biology of the tomato pinworm, T. absoluta on tomato, potato and brinjal

Tomato, potato and brinjal plants were grown singly in plastic pots. The host plants with four to five leaves stage were placed in rearing cages. In each cage, one pair (male and female) of *T. absoluta* were released for oviposition (Sridhar *et al*., 2015; Desneux *et al*., 2010) [12, 4]. Duration of all the stages of the pest on different hosts were recorded. During the observations, temperature was maintained at 25±20C and RH of 75±2 per cent. On daily basis, cotton dipped in 10 per cent honey solution was provided for adult moths. The experiments were repeated for three generations continuously and the data regarding egg period, instarwise larval period, pupal period, adult longevity, total life period fecundity and sex ratio were recorded on tomato, potato and brinjal plants. The data were analysed adopting Completely Randomised Design (CRD).

Egg period

The eggs laid by each of the female were observed for egg hatching. The egg period was recorded from those eggs laid by each female. The average egg period was worked out.

Larval period

The larvae just hatched, neonate larvae were provided daily with fresh leaves. These larvae were observed daily for development and duration of larval instars was expressed in days. Four such instars were noted and duration of each instar was recorded. Average duration of each instar was worked out.

Pupal period

The same larvae which were about to pupate were kept under observations for calculating duration of pupal period. Each pupa was observed till adult emergence and then average pupal period was worked out.

Adult longevity

The longevity of adults in each pair was recorded and average of such individuals was worked out.

Total life period

Total life period from egg to adult was recorded and average of such individuals was worked out.

Fecundity

A pair of adults (male and female) was confined to oviposition cages and number of eggs laid were recorded daily. Fifteen pairs of adults were released separately to work out mean fecundity. The total number of eggs laid by each female in its entire lifetime was recorded and expressed in terms of number of eggs/female. During this period, the pairs were provided with 10 per cent honey solution.

Pupal recovery (%)

Number of pupae recovered from the initial number of eggs inoculated.

$$\% \text{ Pupal recovery} = \frac{\text{Number of pupae obtained}}{\text{Total number of eggs inoculated}} \times 100$$

Sex ratio

Sex ratio was worked out on the basis of males and females emerged out from the pupae kept under observations for calculating the pupal period. Sex determination of *T. absoluta* was done during pupal stage based on size of the pupa.

3. Result and discussion

The biology of *T. absoluta* on tomato, potato and brinjal were studied in the laboratory and the egg period, instarwise larval period, pupal period, adult longevity, total life period, fecundity, sex ratio are presented in Tables 1, 2.

Egg period

The egg period was significantly more in brinjal (6.12 days) compared to potato (4.91 days) and tomato (4.57 days) (Table 1 and Fig.1). Eggs were oval, cylindrical and creamy white to yellow in colour and usually laid singly on the underside of leaves, on buds, or on the stem of seedlings. The results of present study was in comparable with the findings of Halder *et al.* (2017) [7] who reported the the duration of *T. absoluta* egg was 4.23 days. The results of present study are in close agreement with the findings of Erdogan and Babaroglu (2014) [6] who reported that the egg period of *T. absoluta* on tomato was 4.10 days. Desneux *et al*. in the year 2010 [4] studied the biology of *T. absoluta* on tomato and found that the duration of egg period was 4-5 days. These results were on par with our findings (4.57 days). Similarly, the results of present studies are in concurrence with the findings of Sridhar *et al*. (2015) [12] that the egg period of *T. absoluta* was fastest (3.75 days) on tomato followed by potato (5.10 days) and eggplant (6.10 days).

First instar larva

The first instar larval duration was significantly more in brinjal (3.02 days) as compared to potato (2.92 days) and tomato (2.31 days) (Table 1 and Fig.1). The larva of *T. absoluta* had three moults and four instars. The larvae were small, creamy white with black head. The results of present study are in close agreement with the findings of Sridhar *et al*. (2015) [12] who reported that the first instar lasts for 2.0 days (tomato), 2.75 days (potato) and 3.05 days (brinjal). The results of present study are in consonance with the findings of Nayana and Kalleshwaraswamy (2015) [9] who reported that the first instar lasts for 3.25 days.

Second instar larva

The second instar larva closely resembled the first instar larva, but larger in size (Plate 8c). It was white in colour and capable of locomotion. The second instar period was significantly more when it was grown on brinjal (3.45 days) as compared to potato (2.90 days) and tomato (2.29 days) (Table 1 and Fig.1). The results of present study are in close agreement with the findings of Sridhar *et al*. (2015) [12] who reported that the second instar lasts for 1.75 days (tomato), 2.75 days (potato) and 3.0 days (brinjal). Nayana and Kalleshwaraswamy (2015) [9] also recorded that the developmental period of second instar larvae of *T. absoluta* on tomato was in the range of 1.5-3.0 days.

Third instar larva

The third instar larva was green in colour and more active compared to first and second instars. The third instar larval period was significantly more in brinjal (4.64 days) as compared to potato (4.07 days) and tomato (3.28 days) (Table 1 and Fig.1). These results are corroborated with the findings

of Sridhar *et al*. (2015) [12] who reported that the third instar lasts for 1.85 days (tomato), 2.7 days (potato) and 3.1 days (brinjal). The average period of third instar larvae of *T. absoluta* was 2.45 days on tomato (Nayana and Kalleshwaraswamy, 2015) [9].

Fourth instar larva

The fourth instar larva was easily recognised by the presence of pinkish tinge on the dorsal surface of larva. The head and mandibles appeared dark brown in colour. The fourth instar larval period was significantly more in brinjal (5.59 days) as compared to potato (4.26 days) and tomato (3.26 days) (Table 1 Fig.1). The results of present study are in conformity with the findings of previous workers; Nayana and Kalleshwaraswamy (2015) [9] reported that the fourth instar lasts for 3.89 days on tomato. In the same year, Sridhar *et al*. also reported that the fourth instar larvae lasts for 2.3 days (tomato), 3.2 days (potato) and 5.15 days (brinjal). The results of present study was in close agreement with the findings of Manoj *et al*. (2017) [11] who reported that the fourth instar larvae lasts for 3.43 days.

Pupal period

Pupa was light to dark brown, formed under, rolled/folded leaves, singly. The pupa remained in the larval gallery inside folded leaves and sometimes in the soil. The pupal period was significantly more in brinjal (9.81 days) as compared to potato (9.53 days) and tomato (7.43 days) (Table 1 and Fig. 1). These results of present study are in concord with the report of Sridhar *et al*. (2015) [12] who found that the pupal period lasts for 7.95, 9.55 and 10.8 days on tomato, potato and brinjal, respectively. Desneux *et al*. (2010) [4] also studied the biology of *T. absoluta* on tomato and found that the average pupal period was 9-11 days. The results of present study was in comparable with the findings of Polat *et al*. (2016) [15] who reported that the pupal period ranged from 7.52-20.62.

Adult longevity

The moths were small when compared to other lepidopterans and silvery gray in colour with black spots on the forewings. Antenna were filiform with segments. Legs and palps were ringed with black and brown, labial palpi prominent, projected forward and up- curved. The adult longevity was significantly more in tomato (9.63 days) followed by potato (8.74 days) and brinjal (7.55 days) (Table 1 and Fig.1). Estay (2000) [5] reported that adult lifespan of *T. absoluta* on tomato was ranged from 6 to 7 days. Our results were in contradictory with the findings of Attwal *et al*. (2015) [1] who studied the life history of *T. absoluta* on tomato plants and found that adult longevity *T. absoluta* was 13.6 days.

Total life period

The total life period was significantly more in brinjal (32.79 days) as compared to potato (37.35 days) and tomato (39.20 days) (Table 1 and Fig. 1). The results of present investigation are in conformity with the findings of Estay (2000) [5] who reported that average life period of *T. absoluta* was 29- 38 days. In contrary to the results of present study, Desneux *et al*. (2010) [4] reported that the average life period lasts for 26-31 days.

Fecundity

The number of eggs laid by a female varied from host to host. The number of eggs laid per female was significantly more in tomato (151.31 eggs) followed by potato (57.26 eggs) and brinjal (34.5 eggs), respectively (Table 2 and Fig. 2). The result of present study was on par with the findings of Torres *et al*. (2010) [15] who reported that the fecundity ranged from 60 to 120 eggs. The results of present investigation are in close agreement with the findings of Polat *et al*. (2016) [15] who reported that the fecundity of *T. absoluta* was 75.5-138.4 eggs. The result of present study was comparable with the findings of Mahdi *et al*. (2011) [8] who reported that fecundity ranged from 28-260 eggs. Based on the above findings, the egg, larval and pupal periods were significantly lower in tomato compared to potato and brinjal. Further, the adult longevity and fecundity were significantly more in tomato as compared to potato and brinjal. In view of short life cycle completed with high fecundity, it can be attributed that tomato is favourable host for *T. absoluta* compared to potato and brinjal.

Sex ratio

The percent of males and females developed was significantly more on tomato (59.26 males, 40.73 females) followed by potato (55.95 males, 44.04 females) and brinjal (62.16 males, 37.83 females), respectively (Table 2 and Fig. 3). The results of present investigation are in conformity with the findings of Shiberu and Getu (2017) [14] who reported that the sex ratio as 48 males and 32 females out of the eggs laid by single female on tomato in the laboratory.

Table 1: Developmental period of different stages of tomato pinworm, *T. absoluta* on tomato, potato and brinjal.

Host plant	Duration (days)							
	Egg (days)	I instar (days)	II instar (days)	III instar (days)	IV instar (days)	Pupa (days)	Adult (days)	Total life period
Tomato	4.57	2.31	2.29	3.28	3.26	7.43	9.63	32.79
Potato	4.91	2.92	2.90	4.07	4.26	9.53	8.74	37.35
Brinjal	6.12	3.02	3.45	4.64	5.59	9.81	7.55	39.20
CD@0.01%	1.121	0.226	0.532	0.597	0.557	0.623	0.732	3.30
SEm±	0.318	0.064	0.151	0.169	0.158	0.177	0.207	0.93

Mean values presented in the table are average of three replications
The data were analysed using OPSTAT analysis

Table 2: Fecundity and sex ratio of tomato pinworm, *T. absoluta* on different host plants

Host	Fecundity (eggs/female)	Pupa recovery (%)	Sex ratio (%)	
			Male	Female
Tomato	151.31	79.69	59.26	40.73
Potato	57.26	55.99	55.95	44.04
Brinjal	34.5	24.66	62.16	37.83
CD@0.01%	6.806	5.48	4.943	3.628
SE(m)	4.198	1.55	1.401	1.028

Mean values presented in the table are average of three replications
The data were analysed using OPSTAT analysis

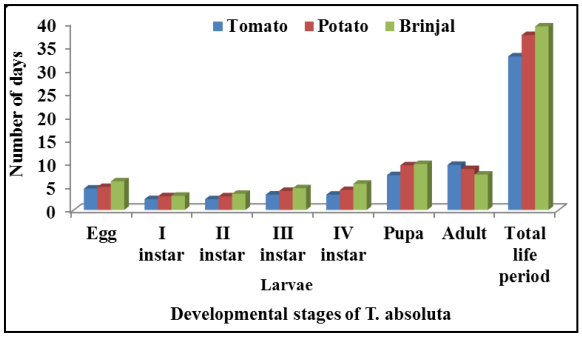

Fig 1: Duration (in days) of tomato pinworm, *T. absoluta* developmental stages on tomato, potato and brinjal.

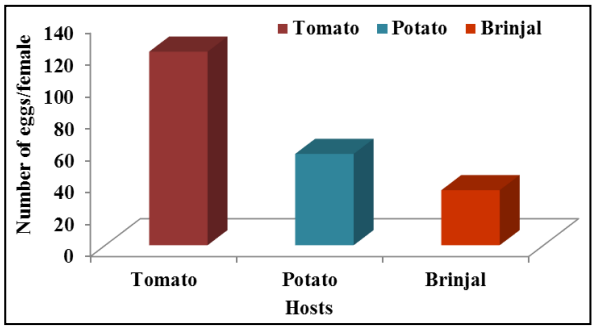

Fig 2: Fecundity of tomato pinworm, *T. absoluta* on tomato, potato and brinjal.

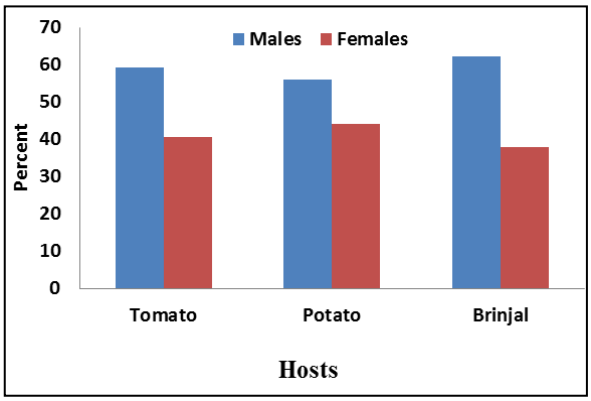

Fig 3: Sex ratio of tomato pinworm, *T. absoluta* on tomato, potato and brinjal.

3. Conclusion

The findings indicated that *T. absoluta* completed the life cycle faster on tomato and the fecundity was also higher on tomato. Hence, it can be ascribed that tomato has been the preferred host compared to potato and brinjal.

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