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Growth Impact of *Tuta absoluta* (Lepidoptera: Gelechiidae), Meyrick, on Tomato Plants and Factors Associated with the Pest Longevity in Nigeria.

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Abstract

Identifying damage pattern and studying the longevity of Tuta absoluta is essential for developing sustainable and effective strategies to manage this pest and mitigate its impact on agricultural systems and food security. The present study aims to elucidate the invasion impact of Tuta absoluta on tomato plants and factors associated with the pest longevity in Nigeria. Rearing of Tuta absoluta were carried out under an average 27.5 ± 3 °C temperature and 75.5 ± 3% relative humidity following standard procedure. Obtained data were analyzed using descriptive analysis and SPSS version 20.0. Subsequently, they were subjected to ANOVA with significance level at P = 0.05. The larval stage represents the destructive phase of Tuta absoluta on tomato plants. Virgin males and females had lifespans of up to 7.3 ± 2.13 and 12.9 ± 3.55 days, respectively, with significantly different values (P<0.05) observed between the sexes. Mating affected longevity of T. absoluta moths. Males lived up to 7.0 +0.15 days while the females lived up to 20.5 + 0.44 days. These values are significantly different at P<0.05. Generally, female live longer than the male counterpart of Tuta absoluta under any condition. It is therefore recommended that the most effective stage to target for control of the pest is typically the larval stage.

Keywords: Tomato, Life-cycle, IPM, Larval stage, Pest control

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INTRODUCTION

When introduced, aggressive exotic insect pests show remarkable capacity for environmental adaptation, which can cause significant destruction to valued crops (Pimentel *et al.* 2000). When they arrive, crop yields are frequently significantly reduced, forcing farmers to devote additional resources to pest management techniques (Bell, 1996; FAOSTAT, 2016). Lepidoptera is the order that includes most invasive insect pests (El-Shafie, 2020). Since its unintentional invasion of Spain in 2006, *Tuta absoluta* (Meyrick) has quickly spread to many parts of the world and is currently acknowledged as the main danger to tomato production globally (Desneux *et al.* 2011; Mahlangu *et al.* 2022).

Reports indicate that *Tuta absoluta* exhibits various developmental stages and inflicts damage on leaves, stems, and fruits of tomato plants (*Solanum lycopersicum*) at any growth phase, resulting in decreased yield and fruit quality (EPPO, 2005; Han *et al.* 2018). Without effective pest control measures, this damage can lead to complete crop loss, reaching up to 100% (Cherif *et al.* 2019; Younes *et al.* 2018). Although tomatoes are its preferred host, *T. absoluta* has been documented to also feed on the foliage of other Solanaceae species, with potatoes (Solanum tuberosum) and eggplants (Solanum melongena) being significant alternative hosts, alongside ten other Solanaceae species (Smith *et al.* 2018; Younes *et al.* 2018).

Research has documented the impact of genetic diversity on the utilization of Solanaceae host plant species by various populations of *T. absoluta* (Ferracini *et al.* 2012; Sylla *et al.* 2019). It is crucial to investigate its association with Solanaceae crops, particularly tomatoes, across different global regions, with special emphasis on Nigeria. In Nigeria, tomato production holds significant economic importance, serving as a cornerstone of the country's agricultural economy (Oke *et al.* 2016; Ogunwale *et al.* 2021).

Understanding how long *Tuta absoluta* can survive in different environmental conditions helps in developing effective pest management strategies. By knowing its lifespan, one can devise control measures that target specific stages of its life cycle to minimize damage to crops. Also, knowledge of *Tuta absoluta*'s longevity aids in predicting population dynamics (Desneux *et al.* 2022). This includes understanding how quickly populations can grow and spread, which is crucial for implementing timely interventions to prevent outbreaks and minimize crop damage. Hence, identifying damage and studying the longevity of *Tuta absoluta* is essential for developing sustainable and effective strategies to manage this pest and mitigate its impact on agricultural systems and food security (Mohamed, *et al.* 2022). Therefore, the present study aims to elucidate the invasion impact of *Tuta absoluta,* novelly, within a simulated natural environment as differ from majority of previous studies on tomato plants and factors associated with the pest longevity collected in Nigeria.

MATERIALS AND METHODS

Study Locations

The experiments were conducted in the Entomological laboratories and screen houses of Department of Crop Protection and Environmental Biology, University of Ibadan, Ibadan, Nigeria, with ambient conditions maintained at approximately 27.5 ± 3 °C temperature and 75.5 ± 3% relative humidity, and 29.2 ± 3 °C temperature and 83.3 ± 4% relative humidity, respectively. Fieldwork (located at 7.4052^{o} N and 3.8500^{o} E) was established at the National Horticultural Research Institute (NIHORT), Ibadan, Oyo State. Additionally, the identification of *T. absoluta* was performed at the Genetic Laboratory of the Institute

Origin and Typical Stock culture of *T. absoluta*

With a few modest modifications, a two-phase approach based on Omoloye (2006) was used to build the stock culture. During the first stage, *T. absoluta* larvae samples were taken from a tomato field and put into a rearing cage, which was a 60 × 60 × 80 cm enclosure made of plastic net. The enclosure was set up with a 16-hour light cycle and an 8-hour dark cycle. These larvae were raised on sweet tomato plants that came from an independent organic tomato farmer's tomato farm at the University of Ibadan's teaching and research farm.

In the second stage, tomato plants in a screen house were exposed to mated females from the F1 generation. After that, the developing F2 instars were carefully moved to rearing cages and fed fresh tomato leaves. In order to maintain a stable culture for ensuing research, this procedure was repeated, providing age-specific cohorts for the study of the biology, lifespan, and effects of the pest on tomato plants.

***Tuta absoluta*: Breeding and Life Cycle**

A group of twenty newly emerged *T. absoluta* individuals were placed in oviposition cages within the laboratory to investigate the life cycle parameters and developmental stages of *T. absoluta,* focusing on the sweet tomato variety. This study aimed to evaluate oviposition, fecundity, and lifespan of mated male and female adults. Pairings were monitored for mating activity in the early morning (0500 – 0800 hours) and evening (1800 – 2000 hours). After mating, pairs were separated and observed for various biological parameters. Subsequently, mated males were crossbred with virgin females and mated females, while virgin males were crossbred with mated females (Oyedokun 2012). Concurrently, another experiment was conducted to examine the pre-oviposition period, post-oviposition period, and oviposition behavior of adult females separately. Additional parameters recorded in the experiment included the incubation period of laid eggs, percentage of egg hatching, and the longevity of mated and virgin adults under different treatments (water, 5% sugar, and 10% sugar). A life table was constructed, and the experiments were replicated five times in a Completely Randomized Design (CRD) as described by Oyedokun (2012) and Bajonero & Parra (2017).

Growth and Life Stages Evaluation of *T. absoluta*

The mean width of the head capsule and the total number of development days from the first instars to the adult moths were used to measure *T. absoluta*'s growth progression.

Adults were sexed upon emergence, and pairs were kept apart in cages. The entire number of eggs, the length of the incubation period, the larval morphometrics (body length, abdominal width, and head capsule width), the number of instars, the developmental period of the instars, the number of days until the adult emerges, and the duration of the adult and life span were all recorded.

Eggs were gathered from rearing cages and cultured separately under ambient conditions of approximately 27 ± 3 ^{o}C temperature and 75 ± 3% relative humidity. Twenty larvae were given sweet tomato leaves to eat after emerging and then placed into separate plastic cages. In order to observe the feeding habits, time intervals between larval stages, developmental process, and behavioral patterns of the larvae, they were given tomato leaves in plastic plates as described by Retta & Berhe, 2015.

The duration of pupation description was used to evaluate *T. absoluta*'s pupal stage. For the assessment of the adult stage, thirty newly emerged adults (both male and female) were collected, sexed, and preserved in 70% alcohol for body length, body width, wingspan, and other morphometric measurements.

Data Analysis

Statistical analysis was conducted using the Statistical Package for Social Sciences (SPSS version 20.0, Inc., Chicago, IL, USA). Data obtained for larval, pupal, and adult morphometrics were analyzed utilizing descriptive statistics. Subsequently, they were subjected to ANOVA, with means differentiated using Turkey's Honestly Significant Difference comparison test at 5% significance level (P = 0.05).

RESULTS

Damage by larvae of *Tuta absoluta*

The larval stage represents the destructive phase of *Tuta absoluta* on tomato plants. Larvae create perforations through the mesophyll. This feeding activity results in conspicuous mines and galleries on leaves, fruits, and stems (Figure 1). These mines and galleries on leaves diminish the photosynthetic capacity, causing premature drying of the leaves (Figure 2). Consequently, other aspects of tomato growth such as flowering and fruiting are affected, particularly when the attack occurs during the early stages of tomato growth.

Figure 1: Tomato leaf damaged by larvae of *Tuta absoluta*

Figure 2: The total defoliation of a tomato plant by larvae of *Tuta absoluta* in the screen house

Factors Affecting Longevity of *Tuta absoluta*

The longevity of *T. absoluta* moths exhibited variations based on sex, feeding, and mating. Virgin males and females had lifespans of up to 7.3 ± 2.13 and 12.9 ± 3.55 days, respectively, with significantly different values (P<0.05) observed between the sexes (Table 1).

Table 1: Effect of sex on the longevity of *Tuta absoluta* moths

Sex of moth	Mean ± SE (days)	Range
Male	7.3 ± 0.13b	6-8
Female	12.9 ± 0.55a	11- 13

N = 20; if the mean ± SE is indicated by the same letter along a column, it implies no significant difference (P > 0.05) based on Tukey's Honestly Studentized Range (HSD) test.

Feeding had a noticeable impact, with an increase in the longevity of female moths fed on 5% significantly (P<0.05) less than those feed with 10% sugar solution. However, males lived for approximately 7.8 ± 0.34 days on a 10% sugar solution significantly (P<0.05) less than males feed with the same sugar concentration (Table 2).

Table 2: Effect on feeding on the longevity of *Tuta absoluta* moths

Sex of moth	Feeding status	Mean ± SE	Range
Male	Water	7.3 ± 0.13b	6 – 8
	5 % sugar solution 10 %	7.5 ± 0.17b	6 – 9
	sugar solution	7.8 ± 0.34b	6 - 8
Female	Water	13.0 ± 0.51a	11 – 16
	5 % sugar solution 10 %	13.9 ± 0.37a	12 – 17
	sugar solution	14.1 ± 0.30a	12 - 17

N = 20; if the mean ± SE is indicated by the same letter along a column, it implies no significant difference (P > 0.05) based on Tukey's Honestly Studentized Range (HSD) test.

Mating affected longevity of *T. absoluta* moths. Males lived up to 7.0 +0.15 days while the females lived up to 20.5 + 0.44 days. These values significantly different at P<0.05 (Table 3). Generally, female live longer than the male counterpart under any condition.

Table 3: Effect of mating on longevity of *Tuta absoluta* moth

Sex of moth	Mean ± SE	Range
Male	7.0 ± 0.15b	6 – 8
Female	20.5 ± 0.44a	18 – 22

N = 20; if the mean ± SE is indicated by the same letter along a column, it implies no significant difference (P > 0.05) based on Tukey's Honestly Studentized Range (HSD) test.

40 (95.24%) larvae survived till 4th instar larval stage. The highest survival rate was recorded at third instar stage (Table 4). The 4th instar larval stage recorded 10% (4) mortality hence only 36 (90%) of the larvae survived to pupal stage. There was 11.11% (4) mortality in the pupal stage, 36 (88.89%) pupae survived to adult emergence. From the 36 pupae that survived to adult emergence seventeen (17) were males emerged and twenty were females (21). The first instar stage had the highest mortality rate at 12.96%, while survival rate was 87.04% (Table 4).

Table 4: Mortality and survival table of *Tuta absoluta*

Parameter		Surviving at start (lx)	Number dying (dx)	Mortality (%)	Survival (%)
Eggs		80	26	32.50	67.5
Larvae	1st	54	07	12.96	87.04
	2nd	47	05	10.64	89.36
	3rd	42	02	4.76	95.24
	4th	40	04	10.00	90.00
Pupae		36	04	11.11	88.89
Adult		32			
			Adult emergence		
		Male		Female	
		13		19	

DISCUSSION

The presence of *Tuta absoluta*, also recognized as the tomato leaf miner (Wang *et al.* 2019), in tomato fields can result in widespread and harmful consequences. Our observations indicate that the larvae of *T. absoluta*, considered the primary destructive stage of this pest, predominantly consume the foliage of tomato plants. They tunnel within the leaves, forming mines and galleries, thereby greatly impairing the plant's photosynthetic capability. This damage to the foliage consequently induces stunted growth, reduced vigor, and premature drying of the leaves. This finding aligns with previous reports highlighting that the larval stage of *Tuta absoluta* poses the greatest threat to tomato production, primarily by feeding on and damaging the leaves of tomato plants. (Fuentes *et al.* 2019; Giakoumoglou *et al.* 2023; Şahin *et al.* 2023).

The longevity of *Tuta absoluta*, is a significant factor to consider in understanding its life cycle, population dynamics, and management strategies. *Tuta absoluta* undergoes a complete metamorphosis, consisting of four stages: egg, larva, pupa, and adult. The larval stage, which comprises the moth phase, is where longevity is most pertinent according to the present study. This aligns with El-Shafie's (2020) findings, indicating that the pest undergoes four developmental stages (egg, larva, pupa, adult) in its life cycle, with females exhibiting notable longevity under various conditions.

To effectively control *Tuta absoluta*, it's important to target its vulnerable stages. The most effective stage to target for control of *T. absoluta* is typically the larval stage. This is because the larvae are the ones that cause the most damage to the tomato plant by feeding on the leaves, stems, and fruits. By targeting the larvae, either through biological control methods, such as introducing natural predators or parasites, or through the use of chemical pesticides, farmers would be able to effectively reduce the population and minimize damage to the tomato crop. Additionally, early detection of the pest and prompt action can help prevent significant infestations (Angon *et al.* 2023).

We additionally suggest prioritizing control measures targeting the female population of the pest. This is due to the females having a longer lifespan, which facilitates multiple reproductive cycles within their lifetime. Thus, it is crucial to eliminate female adults to diminish the overall pest population.

CONCLUSUION

Female *Tuta absoluta* exhibit a longer lifespan compared to their male counterparts, while the larval stage of the pest poses a significant threat to tomato crops. Consequently, the study

concludes that targeting female individuals for control measures will ensure an effective reduction of the pest's impact on agricultural products like tomato plants.

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REFERENCES

Angon, P., Mondal, S., Jahan, I., Datto, M., Antu, U., Ayshi, F., Islam S. (2023). Integrated Pest Management (IPM) in Agriculture and Its Role in Maintaining Ecological Balance and Biodiversity. *Advances in Agriculture*, 2023: 19. https://doi.org/10.1155/2023/5546373

Bajonero, J.G. & Parra, J.R. (2017). Selection and Suitability of an Artificial Diet for *Tuta absoluta* (Lepidoptera: Gelechiidae) Based on Physical and Chemical Characteristics. *J Insect Sci*, 17(1): 13. doi: 10.1093/jisesa/iew105

Bell, J.C. (1996). McGeoch, M.A. An evaluation of the pest status and research conducted on phytophagous Lepidoptera on cultivated plants in South Africa. Afr. Entomol, **4**: 161 170.

Cherif, A., Verheggen, F. (2019). A review of *Tuta absoluta* (Lepidoptera: Gelechiidae) host plants and their impact on management strategies. *Biotechnol. Agron. Soc. Environ*, **23**: 270–278.

Desneux, N., Han, P., Mansour, R., Arnó, J., Brévault, T., Campos, M., Chailleux, A., Guedes, R., Karimi, J., Konan, K., Lavoir, A-V., Luna, M., Perez-Hedo, M., Urbaneja, A., Verheggen, F., Zappalà, L., Abbes, K., Ali, A., Bayram, Y., Cantor, F., Cuthbertson, A., Vis, R., Erler, F., Firake, D., Haddi, K., Hajjar, J., Ismoilov, K., Jaworski, C., Kenis, M., Liu, H-t, Madadi, H., Martin, T., Mazih, A., Messelink, G., Mohamed, S., Nofemela, R., Oke, A., Ramos, C., Ricupero, M., Roditakis, E., Shashank, P., Wan, F-H, Wang, M-h, Wang, S., Zhang, Y-B, Biondi, A. (2022). Integrated pest management of *Tuta absoluta*: practical implementations across different world regions. *J Pest Sci,* **95**: 17–39. https://doi.org/10.1007/s10340-021-01442-8

Desneux, N., Luna, M.G., Guillemaud, T., Urbaneja, A. (2011). The invasive South American tomato pinworm, *Tuta absoluta*, continues to spread in Afro-Eurasia and beyond: The new threat to tomato world production. *J. Pest. Sci*, **84**: 403–408.

El-Shafie, H. (Ed.). (2020). Invasive Species - Introduction Pathways, Economic Impact, and Possible Management Options. *IntechOpen*. doi: 10.5772/intechopen.87502

El-Shafie, H.A. (2020). *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae): An Invasive Insect Pest Threatening the World Tomato Production. In Invasive Species-Introduction Pathways, Economic Impact, and Possible Management Options; IntechOpen: London, UK, 2020; pp. 1–16.

European Plant Protection Organisation (EPPO) (2005). Datasheets on quarantine pests. EPPO **35**:434–435.

FAOSTAT Database (2016). Global tomato production in 2014; Crops/World/2014. UN Food and Agriculture Organization, Statistics Division. 2016. http://faostat.fao.org/faostat. Retrieved 22, March, 2024.

Ferracini, C., Ingegno, B. L., Navone, P., Ferrari, E., Mosti, M., Tavelta, L., Alma, A. (2012). Adaptation of indigenous larval parasitoids to *Tuta absoluta* (Lepidoptera: Gelechiidae) in Italy. Journal of Economic Entomology 105: 1311-1319

Fuentes, A., Yoon, S., Kim, S., Park, D. (2017). A Robust Deep-Learning-Based Detector for Real-Time Tomato Plant Diseases and Pests Recognition. *Sensors*, 17: 2022.

Giakoumoglou, N., Pechlivani, E-M., Frangakis, N., Tzovaras, D. (2023). Enhancing *Tuta absoluta* detection on tomato plants: ensemble techniques and deep learning. *AI* , 4(4): 996-1009; https://doi.org/10.3390/ai4040050

Han, P., Zhang, Y.N., Lu, Z.Z., Wang, S., Ma, D.Y., Biondi, A., Desneux, N. (2018). Are we ready for the invasion of *Tuta absoluta*? Unanswered key questions for elaborating an Integrated Pest Management package in Xinjiang, China. *Entomol. Gen*, **38**: 113 125.

Mahlangu, L., Sibisi, P., Nofemela, R., Ngmenzuma, T., Ntushelo, K. (2022). The differential effects of *Tuta absoluta* infestations on the physiological processes and growth of tomato, potato, and eggplant. *Insects*, **13**(8): 754. https://doi.org/10.3390/insects13080754

Mohamed, S., Niassy, S., Ndlela, S., Obala, F., Mutune, B., Weya, B., Tonnang, H. (2022). Integrated pest management manual for tomato leaf miner (*Tuta absoluta*). *SCLAMP-EA project, icipe - International Centre of Insect Physiology and Ecology,* ISBN 978-9966 063-52-6: *1-44*

Ogunwale, O. G., Oyewale, O.O., Abegunrin, O. O., Kareem, A.T., Adebayo, A. S., Olatunji, B. T. (2021). Perceived benefits of improved practices in pre harvest tomato production among farmers in afijio local government area, oyo state. *Nigerian agricultural journal*, **52**(2): 71-76

Oke, O. A., Kolawole, R. O., Ogunremi, O. A., Akinsola, O. A. and Awe, S. A. (2016). Detection of apanteles spp. (Hymenoptera: Braconidae) larval parasitoid of tomato leafminer *Tuta absoluta* (Lepidoptera: Gelechiidae) on greenhouse tomato in Abeokuta, Ogun state, Nigeria. – 25th International Congress of Entomology – Program Book, Orlando, Florida, USA, p 318.

Omoloye, A. (2006). Sex ratio bias in the F1 adult progeny of African rice gall midge, Orseoliaoryzivora H. and G. (Dipt., Cecidomyiidae). *Journal of Applied Entomology*, 130: 67:349-355 DOI:10.1111/j.1439-0418.2006.01077.x

Oyedokun, A. V. (2012). Bioecology and characterization of tropical warehouse moth, Ephestia cautella Walker (Lepidoptera: Pyralidae) on stored cocoa beans in Southwest Nigeria Phd Thesis Crop Protection and Environmental Biology, University of Ibadan, pp 1-168

Pimentel, D., Lach, L., Zuniga, R., Morrison, D. (2000). Environmental and economic costs of non-indigenous species in the United States. *BioScience*, **50**: 53–65.

Retta, A. N. and Berhe, D. H. (2015). Tomato leaf miner – *Tuta absoluta* (Meyrick), a devastating pest of tomatoes in the highlands of Northern Ethiopia: A call for attention and action. *Research Journal of Agriculture and Environmental Management*. **46**: 264-269

Rubanga, D., Loyani,L., Richard, M., Shimada, S. (2020). A deep learning approach for determining effects of *Tuta absoluta* in tomato plants. *Computer Science,arXiv,* 2020: 212-220

Şahin, Y. S., Erdinç, A., Bütüner, A. K., Erdoğan, H. (2023). Detection of *Tuta absoluta* larvae and their damages in tomatoes with deep learning-based algorithm. *International Journal of Next-Generation Computing*, **14**(3): 77-87. https://doi.org/10.47164/ijngc.v14i3.1287

Smith, J.D., Dubois, T., Mallogo, R., Njau, E.F., Tua, S., Srinivasan, R. (2018). Host range of the invasive tomato pest *Tuta absoluta* Meyrick (Lepidoptera: Gelechiidae) on solanaceous crops and weeds in Tanzania. *Fla. Entomolo*, **101**: 573–579

Sylla, S., Brévault, T., Monticelli, L.S., Diarra, K., Desneux, N. (2019). Geographic variation of host preference by the invasive tomato leaf miner *Tuta absoluta*: Implication for host range expansion. *J. Pest Sci*, **92**: 1387–1396

Wang, Q., Qi, F., Sun, M., Qu, J., Xue, J. (2019). Identification of Tomato Disease Types and Detection of Infected Areas Based on Deep Convolutional Neural Networks and Object Detection Techniques. *Comput. Intell. Neurosci*, 2019: 9142753

Younes, A.A., Zohdy, Z.M.N., Abul, F.H., Fathy, R. (2018). Preference and Performance of the Tomato Leafminer, *Tuta absoluta* (Lepidoptera—Gelechiidae) Towards Three Solanaceous Host Plant Species. *CPQ Microbiol*, **1**: 1–16.