

Rapid Communication

First records of the tomato leaf miner *Tuta absoluta* (Meyrick, 1917) (Lepidoptera: Gelechiidae) in South Africa

Diedrich Visser^{1,*}, Vivienne M. Uys², Roedolf J. Nieuwenhuis³ and Welma Pieterse⁴

¹Agricultural Research Council: Vegetable and Ornamental Plant Institute, Private Bag X293, Pretoria, 0001 South Africa

²Agricultural Research Council: South African National Collection of Insects, Plant Protection Research Institute, Private Bag X134, Queenswood, 0121 South Africa

³Crop Watch Africa, PO Box 211, Komatipoort, 1340 South Africa

⁴Department of Agriculture, Forestry and Fisheries, Plant Quarantine Station, Stellenbosch, 7600 South Africa

Author e-mails: dvisser@arc.agric.za (DV), uysv@arc.agric.za (VMU), roedolff@cropwatch.co.za (RJN), welmap@daff.gov.za (WP)

*Corresponding author

Received: 31 January 2017 / Accepted: 20 April 2017 / Published online: 18 May 2017

Handling editor: John Ross Wilson

Abstract

Tuta absoluta (Meyrick) (Lepidoptera: Gelechiidae) is an invasive and extremely damaging leaf-mining moth of South American origin. It is a serious pest of tomatoes. This species was first recorded outside of its native range in Spain (2006), and has subsequently spread into Asia and Africa. Here we report the first records of this species for the Republic of South Africa, where moths were first trapped in August and October 2016. The species was identified using both morphological and molecular approaches. Monitoring of the spread of tomato leaf miner in South Africa and the implementation of control measures are managed by the Department of Agriculture, Fisheries and Forestry (DAFF), South Africa.

Key words: invasive pest species, Solanaceae, DNA barcoding

Introduction

Tuta absoluta (Meyrick, 1917) is a leaf-mining moth of the family Gelechiidae (Lepidoptera) and is one of the most serious pests of tomato (*Solanum lycopersicum* L.) (Solanaceae) (Desneux et al. 2010). It also attacks other cultivated Solanaceae, such as potato, eggplant, peppers and tobacco (Tumuhaise et al. 2016), although Potting et al. (2013) disputed peppers as a host. Tomato leaf miner (TLM) also feeds on various solanaceous weeds (Chidege et al. 2016).

Tuta absoluta is native to South America and was first reported outside of its native range in 2006, from Spain (Desneux et al. 2010). It has already spread widely through Europe (Desneux et al. 2010), and is currently spreading eastwards into Asia and southwards into Africa. It has invaded numerous sub-Saharan countries, including Nigeria, Niger and Senegal in West Africa (Guimapi et al. 2016) and Tanzania (Chidege et al. 2016) Kenya and Uganda

(Tumuhaise et al. 2016) in East Africa. Through simulations inferred by the moth's ability to cover long distances, the model proposed by Guimapi et al. (2016) accurately predicted *T. absoluta* reaching South Africa in 2016, ten years after its initial detection in Spain; *Tuta absoluta* was first confirmed from South Africa in August 2016.

TLM larvae make blotch leaf mines (Figure 1) and superficial mines on tomato fruit, resulting in the death of plants (Figure 2) or in unmarketable, rotten fruit (Figure 3). Crop losses of 80–100% have been reported from countries in northern and western Africa invaded by TLM (Chidege et al. 2016).

The importance of the tomato leaf miner to tomato production in sub-Saharan Africa was discussed by Brévault et al. (2014). In South Africa, more than 45 pests are known to attack tomato (Visser 2009). Prior to the arrival of the tomato leaf miner, the most important tomato pests in South Africa were spider mites (Acari: Tetranychidae),

American leaf miner *Liriomyza trifolii* (Burgess, 1880) and potato leaf miner *L. huidobrensis* (Blanchard, 1926) (Diptera: Agromyzidae), African bollworm *Helicoverpa armigera* (Hübner, [1809]) (Lepidoptera: Noctuidae), whitefly (Hemiptera: Aleyrodidae) as virus vectors, and semiloopers (Noctuidae) (Visser 2015). Using the CLIMEX modelling platform, Tonnang et al. (2015) predicted a very high likelihood of long-term survival of *T. absoluta* along the southern and eastern coastal areas, and the northern and eastern regions of the Mpumalanga and Limpopo Provinces of South Africa. The newly established presence of the tomato leaf miner will undoubtedly have an impact on the composition of pest complexes, and consequently on current pest control strategies, in particular insecticidal control.

The potato tuber moth, *Phthorimaea operculella* (Zeller, 1873), also a member of the family Gelechiidae, is a major pest of potato (also Solanaceae) and a minor pest of tomato in South Africa (Visser 2009). It inflicts the same type of damage on tomato as the tomato leaf miner, but to a much lesser extent. Although potato is a host of the tomato leaf miner, the risk to potato appears to be limited (EPPO 2005). However, reports indicate that severe simultaneous attacks by the tomato leaf miner and potato tuber moth are possible (Sannino and Espinosa 2010), although differences in cultivar and environment may lead to a higher or lower pest status on potato in South Africa.

Here we report on the first records of *Tuta absoluta* in the Republic of South Africa.

Material and methods

Initial samples of *Tuta absoluta* were trapped in August 2016 from the Komatipoort vicinity and the southern Kruger National Park (KNP) (all Mpumalanga province) (Figure 4) following extensive surveillance by Crop Watch Africa of the entire eastern border of South Africa with Mozambique, using Delta pheromone traps (voucher specimens AcP 9555 – AcP 9558); the traps contained the *Tuta absoluta* pheromone: (E,Z,Z) – 3,8,11 – Tetradecatrienyl 0,76 mg / lure and (E,Z) – 3,8 – Tetradecadienyl 0,04 mg / lure. These original samples were submitted to Dr Martin Krüger (MK), Ditsong National Museum of Natural History, Pretoria, on request of the Department of Agriculture, Fisheries and Forestry (DAFF), South Africa, for verification. This first detection of *T. absoluta* in South Africa was subsequently announced by the International Plant Protection Convention (IPPC 2016). Subsequent material (voucher specimens: AcP 9559) was collected from trap catches from Pretoria. All samples were



Figure 1. Blotch leaf mines caused by *Tuta absoluta* larva. Photograph by D. Visser.



Figure 2. Damage to tomato plants by *Tuta absoluta*. Photograph by R.J. Nieuwenhuis.



Figure 3. Damage to tomato fruit by larva of *Tuta absoluta*. Photograph by R.J. Nieuwenhuis.

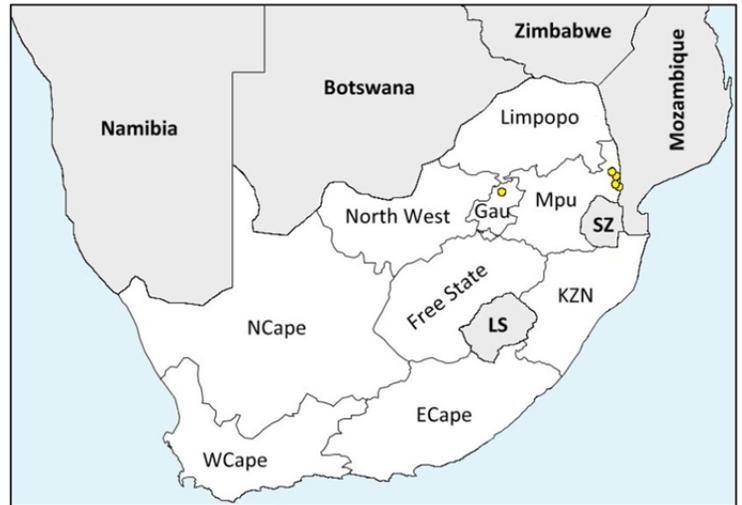


Figure 4. Initial records of *Tuta absoluta* from South Africa. Provinces of South Africa: Gau, Gauteng; KZN, KwaZulu-Natal; Mpu, Mpumalanga. Other countries: LS, Lesotho; SZ, Swaziland.

Table 1. Initial sampling sites of *Tuta absoluta* in South Africa (KNP: Kruger National Park).

Accession Number	Locality	Date	Latitude	Longitude
AcP 9555	Lebombo Border Post, Komatipoort	03.08.2016	25°26'34.55"S	31°59'09.38"E
AcP 9556	Crocodile Bridge Camp, KNP	03.08.2016	25°21'31.37"S	31°53'37.64"E
AcP 9557	Lower Sabie Camp, KNP	03.08.2016	25°07'07.93"S	31°54'56.03"E
AcP 9558	Nkuhlu Picnic Site, KNP	03.08.2016	24°59'49.88"S	31°46'10.25"E
AcP 9559	ARC-VOPI, Roodeplaat, Pretoria	25.10.2016	25°36'03.44"S	28°21'39.55"E

examined and verified by (VMU) using external and internal morphology. Voucher specimens (Table 1) of samples AcP 9555, AcP 9556, AcP 9558 and AcP 9559 are deposited in the South African National Collection, Agricultural Research Council, Plant Protection Research Institute (SANC); sample AcP 9557 was used for molecular analysis.

Total genomic DNA from 20 moths from sample AcP 9557 was extracted at the laboratory of the Plant Quarantine Station, DAFF, Stellenbosch. DNA was extracted with the QIAmp[®] DNA Micro Kit (Qiagen GmbH, Hilden, Germany) according to the manufacturer's protocol. Extracted DNA concentrations were measured with a NanoDrop[®] ND-1000 spectrophotometer (NanoDrop Technologies, Inc.). One nanogram of DNA was used in subsequent PCR amplifications. PCR products of ~658 bp in length were amplified for a fragment of the *COI* gene using the primer pair LCO1490 (5'-GGTCAACAAATCA TAAAGATATTGG-3') and HCO2198 (5'-TAAAC TTCAGGGTGACCAAAAAATCA-3') (Folmer et al. 1994). This primer pair consistently amplifies a 710 bp fragment of the *COI* gene in a wide range of invertebrate taxa (Folmer et al. 1994). The TopTaq MasterMix kit (QIAGEN) was used in all reactions. Thermocycling conditions consisted of denaturation at 95 °C for 1 minute, followed by 35 cycles of 95 °C

for 45 seconds, 51 °C for 45 seconds and 72 °C for 1 minute, with a final extension at 72 °C for 3 minutes. The PCR product was visualized on a 1.2% agarose gel and purified with the Wizard[®] Genomic DNA Purification Kit (Promega Corporation). Purified products were sequenced in both directions using BigDye[®] Terminator v3.1 chemistry (Applied Biosystems) and the same primer pair used for the PCR reactions. Sequences were edited and aligned using CLC Main Workbench 6.9.

Results

Morphological identification

The adult of *Tuta absoluta* is diagnosed by the following characters:

External characters: moth small, body length ca. 6 mm (Figure 5). Forewings narrow, with brown, grey and black mottling; hindwings lanceolate, dark grey with long cilia. Antennae, labial palpi and legs with dark brown and grey banded appearance; antennae long and filiform, labial palpi prominent and curved upward.

Male genitalia (sensu Brambila et al. 2010) (Figures 6 and 7): with hood-shaped uncus, broad at apex; valvae digitate and setose apically, inner margin convex



Figure 5. Left: *Tuta absoluta*, adult (6 mm); right: *Phthorimaea operculella*, adult (8 mm). Photograph by D. Visser.

medially; tegumen broadened basally; gnathos broad, with rounded tip; vinculum broad, well developed, with a long, broad saccus; phallus (Figure 7) with prominent caecum.

The original samples submitted to Dr Martin Krüger were positively identified as *Tuta absoluta*. The internal and external morphology of all samples were examined by (VMU) and were found to conform entirely to the above-mentioned list of characters, thus confirming their identity as *T. absoluta*.

Tuta absoluta moths are similar in appearance to *P. operculella*, which presently is the only other pest of tomato in South Africa with which the tomato leaf miner could be confused. However, in addition to subtle differences in colouration and markings (Figure 5), the potato tuber moth is larger (ca. 8 mm in length) and the male genitalia are distinct, with the valvae being slender and curved apically.

Molecular analysis

The consensus sequence was used in a BLASTN (basic local alignment search tool) search (Boratyn et al. 2013) to find matching sequences (Zhang et al. 2000). This sequence was deposited in GenBank with accession number KY212128. This *COI* sequence (KY212128) matched the *Tuta absoluta* sequences KX443111 and KX443108 (Sint et al. 2016) and JQ749676 from Tunisia (Bettaïbi et al. 2012) with 100% identity.

The molecular data support the morphological studies and confirm the present specimens as *T. absoluta*.

Implications and discussion

Tuta absoluta and *P. operculella* can easily be confused, especially when they co-exist in single cropping systems, as the moths and the larvae are very similar



Figure 6. *Tuta absoluta*: male genitalia (AcP 9559). Photograph by M. Stiller.



Figure 7. *Tuta absoluta*: phallus (AcP 9559). Photograph by M. Stiller.

in appearance and behaviour. Although moth pheromone traps are fairly species-specific, the identity of initial trap catches should be verified by examination of the male genitalia.

The tomato leaf miner is undoubtedly a threat to tomato production in South Africa. The development of resistance of *T. absoluta* populations of diverse

geographic origin to diamide insecticides, a relatively new introduction to the market for the control of *T. absoluta* and other Lepidoptera (Roditakis et al. 2017), as well as varying efficacy of conventional pesticides (Campos et al. 2014), could result in complete destruction of tomato plots by TLM in the future. Small-scale farmers and home gardeners will necessarily be most vulnerable, as many of them may lack the resources required to combat this pest. Urgent research, including investigations into alternative control strategies is therefore imperative. These strategies may include natural control by indigenous predators and parasitoids, the use of pheromone traps for monitoring and mass trapping, and the role of sanitation in reducing infestation levels.

Acknowledgements

Jan Hendrik Venter, Manager: Plant Health Early Warning Systems, Department of Agriculture, Forestry and Fisheries (DAFF), for valuable discussions and information about the first occurrence of *Tuta absoluta* in South Africa. Martin Krüger, Ditsong National Museum of Natural History, Pretoria, who verified the initial identification of *T. absoluta*. Michael Stiller, Agricultural Research Council, Plant Protection Research Institute, Pretoria for photographs of the genitalia. Riaan Stals, of the same institution for valuable advice and comments during the preparation of this paper.

References

Bettaïbi A, Mezghani-Khemakhem M, Bouktila D, Makni H, Makni M (2012) Genetic variability of the tomato leaf miner (*Tuta absoluta* Meyrick; Lepidoptera: Gelechiidae), in Tunisia, inferred from RAPD-PCR. *Chilean Journal of Agricultural Research* 72: 212–216, <https://doi.org/10.4067/S0718-58392012000200008>

Boratyn GM, Camacho C, Cooper PS, Coulouris G, Fong A, Ma N, Madden TL, Matten WT, McGinnis SD, Merezhuk Y, Raytselis Y, Sayers EW, Tao T, Ye J, Zaretskaya I (2013) BLAST: a more efficient report with usability improvements. *Nucleic Acids Research* 41: W29–W33, <https://doi.org/10.1093/nar/gkt282>

Brambila J, Lee S, Passoa S (2010) *Tuta absoluta* the tomato leafminer. Identification aid. USDA Cooperative Agricultural Pest Survey (CAPS). National Agricultural Pest Information System (NAPIS)

Brévault T, Sylla S, Diatte M, Bernadas G, Diarra K (2014) *Tuta absoluta* Meyrick (Lepidoptera: Gelechiidae): a new threat to tomato production in sub-Saharan Africa. *African Entomology* 22: 441–444, <https://doi.org/10.4001/003.022.0202>

Campos MR, Rodrigues AR, Silva WM, Silva TB, Silva VR, Guedes RN, Siqueira HA (2014) Spinosad and the tomato borer *Tuta absoluta*: a bioinsecticide, an invasive pest threat, and high insecticide resistance. *PLoS ONE* 9: e103235, <https://doi.org/10.1371/journal.pone.0103235>

Chidege M, Al-zaidi S, Hassan N, Julie A, Kaaya E, Mrogoro S (2016) First record of tomato leaf miner *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) in Tanzania. *Agriculture & Food Security* 5: 17, <https://doi.org/10.1186/s40066-016-0066-4>

Desneux N, Wajnberg E, Wyckhuys KAG, Burgio G, Arpaia S, Narváez-Vasquez CA, González-Cabrera J, Catalán Ruescas D, Tabone E, Frandon J, Pizzol J, Poncet C, Cabello T, Urbaneja A (2010) Biological invasion of European tomato crops by *Tuta absoluta*: ecology, geographic expansion and prospects for biological control. *Journal of Pest Science* 83: 197–215, <https://doi.org/10.1007/s10340-010-0321-6>

EPPO (2005) European and Mediterranean Plant Protection Organization. Data sheets on quarantine pests. *Tuta absoluta*. *EPPO Bulletin* 35: 434–435, <https://doi.org/10.1111/j.1365-2338.2005.00852.x>

Folmer O, Black M, Hoeh W, Lutz R, Vrijenhoek R (1994) DNA primers for amplification of mitochondrial cytochrome *c* oxidase subunit I from diverse metazoan invertebrates. *Molecular Marine Biology and Biotechnology* 3(5): 294–299

Guimapi RY, Mohamed SA, Okeyo GO, Njijomatchoua FT, Ekesi S, Tonnang HE (2016) Modeling the risk of invasion and spread of *Tuta absoluta* in Africa. *Ecological Complexity* 28: 77–93, <https://doi.org/10.1016/j.ecocom.2016.08.001>

IPPC (2016) First detection of *Tuta absoluta* in South Africa. Report ZAF-31/1. International Plant Protection Convention. <https://www.ippc.int/en/countries/south-africa/pestreports/2016/09/first-detection-of-tuta-absoluta-in-south-africa> (accessed 27 January 2017)

Roditakis E, Steinbach D, Moritz G, Vasakis E, Stavrakaki M, Ilias A, García-Vidal L, del Rosario Martínez-Aguirre M, Bielza P, Morou E, Silva JE (2017) Ryanodine receptor point mutations confer diamide insecticide resistance in tomato leafminer, *Tuta absoluta* (Lepidoptera: Gelechiidae). *Insect Biochemistry and Molecular Biology* 80: 11–20, <https://doi.org/10.1016/j.ibmb.2016.11.003>

Potting RPJ, Van Der Gaag DJ, Loomans A, Van der Straten M, Anderson H, Macleod A, Castrillón JMG, Cambra GV (2013) *Tuta absoluta*, tomato leaf miner moth or South American tomato moth. Ministry of Agriculture, Nature and Food Quality, Plant Protection Service of the Netherlands, PRA, 28 pp

Sannino L, Espinosa B (2010) *Tuta absoluta*: Biology Guide and Integrated Control Approaches. *L'Informatore Agrario*, 46/2010, Supplement 1, 84 pp

Sint D, Sporleder M, Wallinger C, Zegarra O, Oehm J, Dangi N, Giri YP, Kroschel J, Traugott M (2016) A two-dimensional pooling approach towards efficient detection of parasitoid and pathogen DNA at low infestation rates. *Methods in Ecology and Evolution* 7: 1548–1557, <https://doi.org/10.1111/2041-210X.12621>

Tonnang HEZ, Mohamed SF, Khamis F, Ekesi S (2015) Identification and risk assessment for worldwide invasion and spread of *Tuta absoluta* with a focus on sub-Saharan Africa: implications for phytosanitary measures and management. *PLoS ONE* 10: e0135283, <https://doi.org/10.1371/journal.pone.0135283>

Tumuhaise V, Khamis FM, Agona A, Sseruwu G, Mohamed SA (2016) First record of *Tuta absoluta* (Lepidoptera: Gelechiidae) in Uganda. *International Journal of Tropical Insect Science* 36: 135–139, <https://doi.org/10.1017/S1742758416000035>

Visser D (2009) A Complete Guide to Vegetable Pests in South Africa. Agricultural Research Council, Roo-deplaar Vegetable and Ornamental Plant Institute, Pretoria, South Africa, 316 pp

Visser D (2015) Tomato, brinjal and peppers. In: Prinsloo GL, Uys VM (eds), *Insects of Cultivated Plants and Natural Pastures in Southern Africa*. Entomological Society of Southern Africa, Hatfield, Pretoria, South Africa, pp 66–73

Zhang Z, Schwartz S, Wagner L, Miller W (2000) A greedy algorithm for aligning DNA sequences. *Journal of Computational Biology* 7: 203–214, <https://doi.org/10.1089/10665270050081478>