

South American Tomato Leafminer, *Tuta absoluta*: A Serious Threat to California

K. E. Godfrey, Contained Research Facility, University of California, Davis; F. G. Zalom, Dept. of Entomology, University of California, Davis; and J. C. Chiu, Dept. of Entomology, University of California, Davis

The South American tomato leafminer, *Tuta absoluta* Meyrick (Lepidoptera: Gelechiidae) (Figure 1), is a serious and devastating pest of tomatoes, causing crop losses as high as 80 to 100% in areas where it is found. This insect bores into leaves, stems, flowers, and fruit, often leaving the fruit unmarketable (Figure 2) and altering plant growth structure through destruction of stem apical buds or flower buds. To manage this insect, growers may be forced to greatly increase the number of insecticide applications to their tomato crops.

South American tomato leafminer spreads via commercial trade of plants and fruit infested with eggs, larvae, and pupae. The adult moths can fly, but it is not known if this movement contributes significantly to its spread. There are numerous regulations in place that should limit the spread of the South American tomato leafminer in imported commercial tomato plants and fruit. However, movement of fruit and plants by private individuals is not as strongly regulated.

The South American tomato leafminer is currently found in most countries of South America, in Panama and Costa Rica, and is slowly moving northward through Central America. In 2007, this leafminer was found in a few greenhouse tomato production facilities in Spain. Despite extensive efforts to slow the migration of this insect, it spread throughout southern Europe in only about 3 years. Its rapid spread continues throughout North Africa and into West Asia.

Although it has not yet been found in California, projections from computer models suggest that the South American tomato leafminer will eventually establish in California, where it is likely to become a serious threat to tomato production. Monitoring, identification, and reporting of this pest can help slow its spread into California. This publication provides information to assist the public in identifying possible introductions of the South American tomato leafminer.

Life Cycle and Identification

Identifying the South American tomato leafminer can be difficult, due to the existence of similar-looking tomato pests found in California, such as the tomato pinworm and potato tuberworm (Figure 3). The adult moths of the South American tomato leafminer and the tomato pinworm are identical morphologically, and the damage inflicted by the larvae of each of these pests is very similar.



A. MUSSOLL

Figure 1. South American tomato leafminer larvae damaging leaf.



J. RIUDAVETS

Figure 2. Fruit damage caused by South American tomato leafminer larvae.



Figure 3. Adult South American tomato leafminer (left), adult tomato pinworm (middle); adult potato tuberworm (right)



J. ARNO

Figure 4. South American tomato leafminer eggs on the underside of a leaf.

South American tomato leafminer adults are small, silvery-brown moths, about 3/16 of an inch (4.5 mm) in length. They are most active at dusk and dawn, and rest on leaves and other plant parts during the day. Female moths lay eggs on different plant parts (e.g., the underside of leaves, petioles, blossom, fruit), either singly or in small batches. A female moth may lay up to a maximum of 260 eggs in her lifetime. The eggs are yellow (Figure 4), turning darker about a day before hatching. At 80°F, the eggs hatch in 4 to 7 days.

The newly emerged larva (caterpillar) penetrates the plant tissue on which the egg was laid and begins to feed, resulting in leaf mines (Figure 5), stem mines, or damage to the inside of a fruit (Figure 6). The larva is cylindrical in body shape with a distinct head and legs (Figure 7). The young larvae are light yellow to green and very small, about 1/64 of an inch (0.5 mm) in length. As the larva grows, it becomes darker green. A larva completes 4 stages of growth (larval instars) in about 12 to 16 days at 80°F.

The larvae of the South America tomato leafminer and tomato pinworm are also very similar in appearance, especially when very young. Newly emerged larvae of both species are white or cream-colored. Although it is nearly impossible to visually distinguish the newly emerged South American tomato leafminer from the newly emerged tomato pinworm (Figure 8), the young larvae are discernible from other newly hatched common larvae such as the tomato fruitworm, *Helicoverpa* (= *Heliothis*) *zea*, (Figure 9) or tobacco budworm, *Heliothis virescens*, both of which have more noticeable rows of



J. ARNO

Figure 5. South American tomato leafminer larvae in leaf mines.



A. MUSSOLL

Figure 7. South American tomato leafminer, young larva.



J. K. CLARK

Figure 9. Tomato fruitworm larva (*Helicoverpa zea*). Note darker colored pronounced tubercles.



M. VAN DER STRATEN

Figure 11. South American tomato leafminer older larva. Note distinct dark line (prothoracic shield) just behind head.



J. RIUDAVETS

Figure 6. Fruit damaged by South American tomato leafminer larvae.



J. K. CLARK

Figure 8. Tomato pinworm. Newly hatched tomato pinworm and South American tomato leafminer larvae are nearly identical. Note dark head hidden in photo.



J. K. CLARK

Figure 10. A leafminer fly larva, showing the lack of legs and of a distinct head.



J. K. CLARK

Figure 12. Tomato pinworm older larva has a less distinct black line behind head.

protruding tubercles sprouting one or two hairs.

In addition, these larvae are distinguishable from leafminers that will develop into flies, such as the American serpentine leafminer *Liriomyza trifolii*, because the larvae of the moth pests have distinct heads and small legs. The leafminers that develop into flies are cylindrical in shape and do not have distinct heads or legs (Figure 10).

The South American tomato leafminer and tomato pinworm larvae in older life stages start to exhibit some morphological characteristics that may help in identification. Although both larvae vary in color from brownish-pink to green, the South American tomato leafminer has a stronger black line (prothoracic shield) just below its head (Figure 11) compared to that of the tomato pinworm (Figure 12). Samples,

however, should be submitted to your local agricultural commissioner's office (California Department of Food and Agriculture) for expert identification.

After the fourth instar, the larva may leave the leaf mine or fruit gallery to form a pupa (Figure 13) where it will undergo transformation into an adult moth (Figure 14). The pupa can be found in a silken cocoon either folded into the edge of a leaf or on the soil surface. At temperatures of 80°F, the pupal stage lasts about 7 to 9 days, completing its entire life cycle in about 23 to 32 days. The insect will continue to complete life cycles as long as host plants are present and temperatures favor its development.

The South American tomato leafminer prefers to feed on tomato, but when tomatoes are not available, it can feed and reproduce on alternate hosts such as potato, eggplant, pepper, and solanaceous weeds like black nightshade or hairy nightshade. However, its reproductive potential on the alternate hosts is much lower in comparison to tomato.

Damage

Just like the tomato pinworm, the South American tomato leafminer damages tomato plants by mining the leaves (Figure 15) and boring into the apical and flower buds and fruits. The newly hatched larvae penetrate the plant tissue and begin to feed,



J. ARNÓ



M. MATAS

Figure 13. South American tomato leafminer pupa.

Figure 14. Female and male South American tomato leafminer moths.



J. ARNÓ

Figure 15. Leaf mining by South American tomato leafminer larvae.



J. RIUDAVETS

Figure 16. Fruit damaged by apical boring by South American tomato leafminer larvae.



J. K. CLARK

Figure 17. Pinworm-damaged fruit (calyx has been removed).



A. MUSSOLL

Figure 18. Blotch-type mines of the South American tomato leafminer. Tomato pinworm mines are nearly identical in appearance.



J. K. CLARK

Figure 19. Narrow serpentine mines of fly vegetable leafminers.



D. RILEY

Figure 20. Overlapping fly leafminer mines can resemble blotch-type mines.

resulting in irregularly shaped mines that increase in size as the larva grows. Eventually the larva may leave the original mine and move to another part of the leaf or plant to feed. Sometimes the larger larvae can be found hanging from silken threads as they move around the tomato plant.

Larvae feeding inside a developing shoot or bud can cause the bud to die, resulting in poor plant architecture and fruit set. Young larvae burrowing into the fruit form large enclosed holes, or galleries, where they feed. The leaf mines and the galleries in the fruit may be invaded by secondary pathogens, resulting in necrotic areas on the leaf and rotting fruit (Figure 16).

As previously stated, the tomato pinworm (*Keiferia lycopersicella*) and various fly vegetable leafminers (*Liriomyza sativae* and *L. trifolii*) can cause similar-looking mining damage to tomato leaves or fruit (Figure 17).

Tomato pinworm and the South American tomato leafminer both form “blotch-type” mines in leaves, which grow in size as the caterpillar grows. These larger mines often contain visible excrement; occasionally the caterpillar can be seen in the mine as well (Figure 18).

In contrast, the mines of fly vegetable leafminers are narrow, serpentine paths meandering in a maze-like fashion across the leaf (Figure 19). The small, yellow, legless larva (maggot) and its excrement are rarely visible from the surface of the leaf. Occasionally, many overlapping mines of fly leafminers can resemble the blotch-type mines of the pinworm and the South American tomato leafminer (Figure 20).

The South American tomato leafminer and tomato pinworm cause nearly identical damage to the tomato fruit (Figures 16 and 17 respectively). Both caterpillars bore into the fruit surface, leaving only a surface hole or yellowish mine. It is generally difficult to distinguish fruit damage between the two pests.

Guidelines

The South American tomato leafminer is considered to be one of the most important insect pests of tomato in areas where it is already established. In newly invaded areas, it can cause complete loss of tomato crops. Managing this insect currently relies mainly on repeated insecticide applications, thus leading to an increased risk of insecticide resistance.

More recent studies conducted in commercial tomato production are investigating the integration of biological control with insecticides to provide a more sustainable pest management program for this insect. In addition, there are numerous regulations and quarantines in place, both in areas where the South American tomato leafminer is established and in the United States where the leafminer has not been found, which attempt to slow the spread of this potentially devastating pest.

The best way to identify the South American tomato leafminer and prevent its establishment in California is to submit any samples of leaves or fruit with possible South American tomato leafminer leaf mines or larvae to your local county agricultural commissioner office; complete a California Department of Food and Agriculture “Report a Pest” form found at <http://www.cdffa.ca.gov/plant/reportapest/form/reportapestform.pdf>; or call the CDFA Pest Hotline at 1-800-491-1899.

Rapid discovery of the first introduction of this devastating pest will allow regulators and others more options to mitigate the effect of the introduction and limit the impact of this pest on California tomato production.

Acknowledgments

Photos provided by J. Arnó, J. Riudavets, R. Gabarra, A. Mussoll, M. Matas, and the UC Statewide IPM Program. This publication was supported by the Specialty Crop Block Program at the U.S. Department of Agriculture (USDA) through Grant 14-SCBGP-CA-006. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the USDA.