Monitoring for beneficial wasps

Idiobiont parasitoids:

SLM larvae which have been attacked by idiobiont parasitoid wasps (Fig. 5a) are immediately paralysed and never emerge from the leaf mine. Thus, counting *living* larvae (i.e. those actively feeding inside leaf mines) or pupae that have emerged from leaves avoids counting any larvae that were already attacked by idiobiont wasps, which would inflate the SLM population size estimate. Idiobiont ectoparasitoids* (which develop outside the body of the fly) can be observed inside leaf mines through a hand lens as either a larva, often found in close proximity to a dead leafminer larva (Fig. 5b), or as a pupa, flanked by black dots called meconial pillars (Fig. 5c).

In summary: Signs of idiobionts can be observed inside leaf mines via a hand lens (Fig. 5b/c)

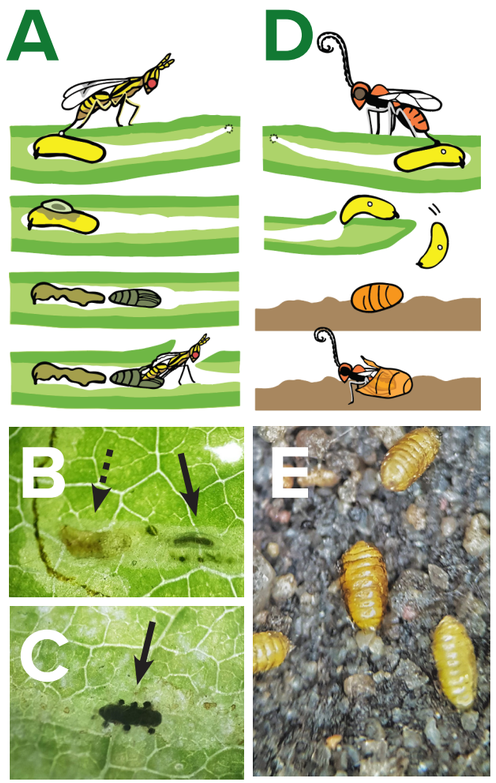
Koinobiont parasitoids:

SLM larvae which have been attacked by koinobiont wasps are NOT paralysed. They continue feeding and successfully pupate. Thus, counting living larvae or pupae that have emerged from leaves may still inflate the SLM population size estimates, because these counts may include individuals that will ultimately perish during the pupal stage. Koinobiont endoparasitoids (which develop inside the body of the fly) emerge from otherwise healthy looking leafminer pupae. Thus, pupae must be retained in rearing vessels for several weeks to confirm activity of these wasps.

In summary: There are no signs of koinobiont parasitism until emergence of adults from otherwise healthy looking fly pupae.

**some idiobionts are endoparasitoids, which pupate inside the dead fly larva, and thus may be less visible within the mine, however this is a minority of species*

Fig 5. Parasitoid lifecycles



A) An idiobiont ectoparasitoid lifecycle and signs of idiobiont parasitism under a microscope or hand lens, including B) a wasp larva (solid arrow) near a leafminer larva carcass (dotted arrow); and C) a wasp pupa inside a leaf mine (solid arrow). D) A koinobiont endoparasitoid lifecycle. E) There are no signs of koinobiont parasitism before emergence of adult flies and wasps from the fly puparium.

References

"Management of leafmining flies in vegetable and nursery crops in Australia" guide and "Preparedness for the exotic vegetable leafminer in vegetable and nursery crops in Australia" guide: https://ausveg.com.au/biosecurity-agrichemical/biosecurity/mt16004/#extension_package

Hort Innovation Project MT16004 Final Report: https://www.horticulture.com.au/growers/help-your-business-grow/research-reports-publications-fact-sheets-and-more/mt16004/

Heinz, K. M. & Chaney, W. E. Sampling for Liriomyza huidobrensis (Diptera: Agromyzidae) larvae and damage in celery. Environ. Entomol. 24, 204–211 (1995).

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Images and illustrations by Elia Pirtle unless otherwise specified

Management strategy for serpentine leafminer, Liriomyza huidobrensis (MT20005) is a strategic levy investment under the Hort Innovation Vegetable, Potato, Onion and Nursery Funds. This project has been funded by Hort Innovation using the vegetable, potato, onion and nursery research and development levies and contributions from the Australian Government. Hort Innovation is the grower-owned, not-for-profit research and development corporation for Australian horticulture.

Monitoring for serpentine leafminer in Australia

Resource prepared as part of Hort Innovation project MT20005; May 2021 Version

About the pest

The serpentine leafminer (SLM; *Liriomyza huidobrensis*), is a well known global pest of vegetable and ornamental crops. It was first detected in Australia in October 2020, and is presently found in New South Wales and Queensland.

Actual size: 1.5-2.5 mm

Overseas experiences tell us that monitoring is a cornerstone of a successful IPM approach to managing SLM. Monitoring goals may include:

- detecting early infestations, particularly in young crops or crops for which leaf mine damage reduces marketability, such as ornamentals, lettuce and celery;
- estimating population density in larger infestations, in order to apply economic thresholds to chemical applications and to monitor the success of interventions.

This guide summarizes monitoring techniques that support each of these goals*. Each technique has benefits (✓) and drawbacks (–) and can be used in combination to effectively monitor SLM populations in Australia.

Detecting early infestations

1. Focus monitoring using predictive tools:

Monitoring is most important when crops are at vulnerable stages, or when climatic conditions make outbreak risk highest. The following tools can help identify high risk periods to guide timing of monitoring:

- The SLM seasonal activity predictor: This tool (currently in prototype stage) shows estimated activity potential for SLM across region and season within Australia. https://cesaraustralia.shinyapps.io/SLMseasonalactivity/
- The DARABUG2 lifecycle duration predictor: This tool (Fig. 1) predicts life stage durations of SLM across region and season within Australia. https://cesaraustralia.shinyapps.io/darabug2/

DARABUG2 life-cycle predictor

SLM seasonal activity predictor

2. Conduct a visual survey:

Look for signs of leafmining damage (Fig. 2) in crops to detect infestations early. For instructions, see the **Hort Innovation "Preparedness for the exotic vegetable leafminer in vegetable and nursery crops in Australia" guide**, which is also relevent for SLM. If transplanting plants, carefully check them both before and after transplanting. Plants that show no signs of SLM could contain eggs, which are invisible and take several days before hatching (use the DARABUG2 tool to predict the length of the egg phase).

3. Monitor for adults via sticky traps

Commercially available yellow sticky traps attract adult SLM and are especially valuable for population monitoring in closed cropping, or around young crops to indicate when adult flies may be moving into the crop (potentially from a sequential crop nearby). However, catches relate poorly to crop damage, population sizes and parasitoid activity. Traps should be hung at about plant canopy height and checked within one week.

- ✓ useful for a variety of invertebrate species
- – difficult to relate to population size or crop damage
- – underestimates parasitoid activity

In summary: Ideal for monitoring for early infestations and flights within and between farms, but poor for determining population densities

** For information on differentiating between SLM and morphologically indistinguishable non-pest* Liriomyza *species present in Australia, including the cabbage leafminer (*Liriomyza brassicae*) and the beet leafminer (*Liriomyza chenopodii*), see* ***Appendix 10 (SLM Contingency Plan) of Hort Innovation Project MT16004 Final Report****.*

Estimating population density of larger infestations:

Possible sampling techniques include:

- Counting infested leaves with signs of damage (incl. leaf mining and stippling on leaves)
- Counting live larvae within leaves
- Counting puparia caught in pupal trays or emerged from leaf collections
- Counting adults on yellow sticky traps or emerged from pupae collections

Counting infested leaves

The number of leaves bearing leaf mines in a subset of leaves on a subset of randomly selected plants may be counted. However, **the presence of leaf mines is not always enough to determine if intervention is warranted**. Leaf mines may be old, or may contain more parasitoids than fly larvae (Fig. 3). In both cases, insecticide application would be inappropriate.

- ✓ easy to see leaf mines and stippling damage (Fig. 2)
- ▬ can overstimate population activity and encourage inappropriate interventions

In summary: Preferred when the goal is to detect early infestations, but may be innappropriate when monitoring the extent of an infestation or the success of an intervention

Counting live larvae

The number of 'active' mines in a subset of leaves on a subset of randomly selected plants can be counted by checking mines for live larvae (Fig. 3a/b) using a hand lens.

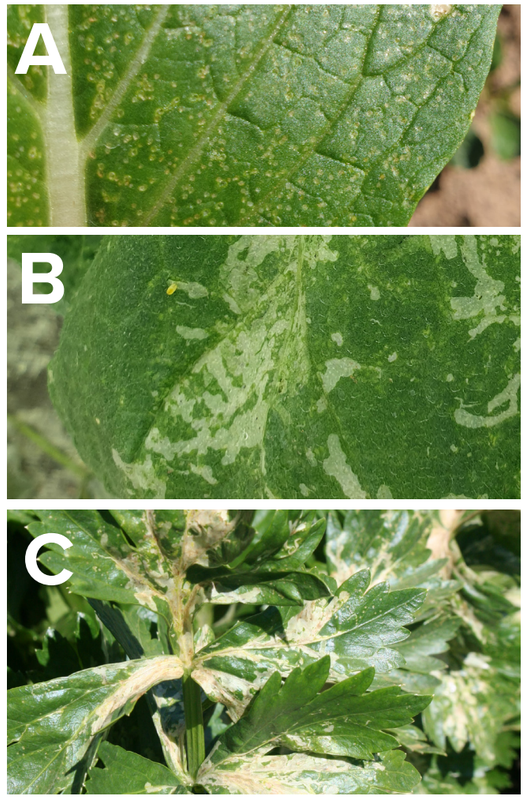
- ✓ accurate measure of population density
- ✓ accounts for idiobiont ectoparasitoid activity*
- ▬ requires a hand lens and close inspection of leaves
- ▬ underestimates koinobiont endoparasitoid activity*

In summary: Gives an accurate population size estimate and is a key component of sampling plans aimed at using economic thresholds (ETs)

Overseas example

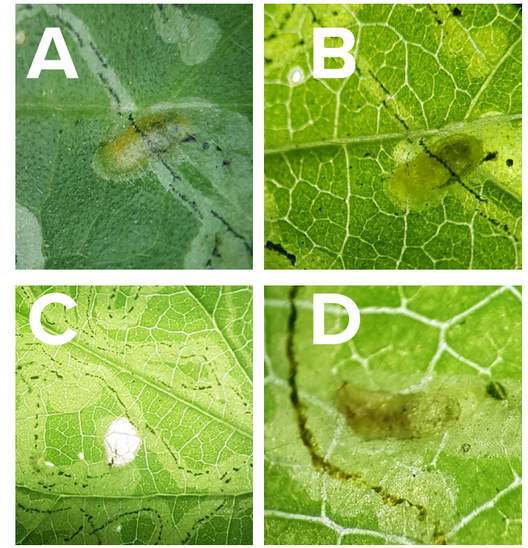
Heinz and Chaney (1995) developed the following plan for SLM in celery in California: Count either mines or active mines in 1 randomly selected petiole per plant from randomly selected plants until a density determined stopline is reached. If the population density is greater than an average 17 live larvae or 19 mines per 100 petioles, no more than 100 petioles will be required

Figure 2. Leafminer damage symptoms



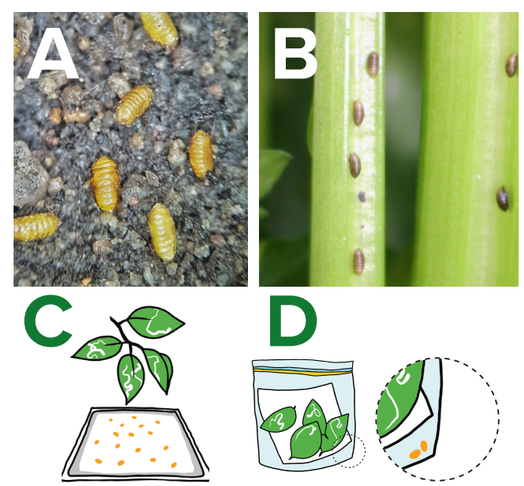
Damage caused by adult leafminer. A) SLM stippling damage to choy sum. Photo by: Shannon Mulholland, NSW DPI; B) SLM damage to cucumber. Photo by: Shannon Mulholland, NSW DPI; C) SLM damage to celery. Photo by: John Duff, DAFF

Figure 3. Spotting larvae inside mines



A) Live larvae (VLM pictured but larvae are indistinguishable from SLM) can be seen feeding via a hand lens; B) holding the leaf up to the sun can increase visibility; C) inactive mines may be empty; or D) may contain a dead larva

Figure 4. Counting pupae in pupal trays or plastic bags of leaf collections



A) Small orange pupae (~2mm; VLM pictured but pupae are indistinguishable from SLM) accumulate in soil beneath infested plants. B) SLM pupae may collect on plant surfaces. Photo by: John Duff, DAFF. Pupae collect into C) pupal trays placed underneath plants; or D) into the bottom of plastic bags of leaf collections

Counting pupae via pupal trays or leaf collections

Leafminer activity can be measured by collecting mature larvae which have fallen into polystyrene or plastic trays (pupal trays, between 8 x 11 to 12 x 15 inches in size) and pupated over a period of 3-4 days (Fig. 4b). See the **Hort Innovation "Management of leafmining flies in vegetable and nursery crops in Australia" guide** for more information on their use.

Pupae may also be counted by collecting a subset of leaves from a subset of randomly selected plants into plastic bags, and observing the number of pupae that emerge and collect into the bottom of the bag.

- ✓ accounts for idiobiont ectoparasitoid activity*
- ✓ does not require a hand lens as pupae are easier to observe and count after emergence
- ▬ underestimates koinobiont endoparasitoid activity*

In summary: Popular method overseas due to being an easily visual indicator of whether leaf mine damage is caused by an active infestation, or whether the damage is old and thus intervention may be unwarranted; gives accurate population size estimates and can be used with ETs

NOTE: The pupae collected via pupal trays or via leaf collections may be retained in order to assess the level of parasitism by koinobiont endoparasitoids (see page 4). Pupae may be kept in a plastic bag (Fig. 4c) with a damp paper towel, out of direct sunlight, until adult flies or wasps emerge and adult flies may be counted

- ✓ accounts for idiobiont ectoparasitoid and koinobiont endoparasitoid activity*
- ▬ it can take multiple weeks for all adult flies to emerge (see DARABUG tool) and wasps even longer, thus not suitable for quick decisions

** see page 4 for explanation of idiobiont and koinobiont parasitoid and monitoring for them*