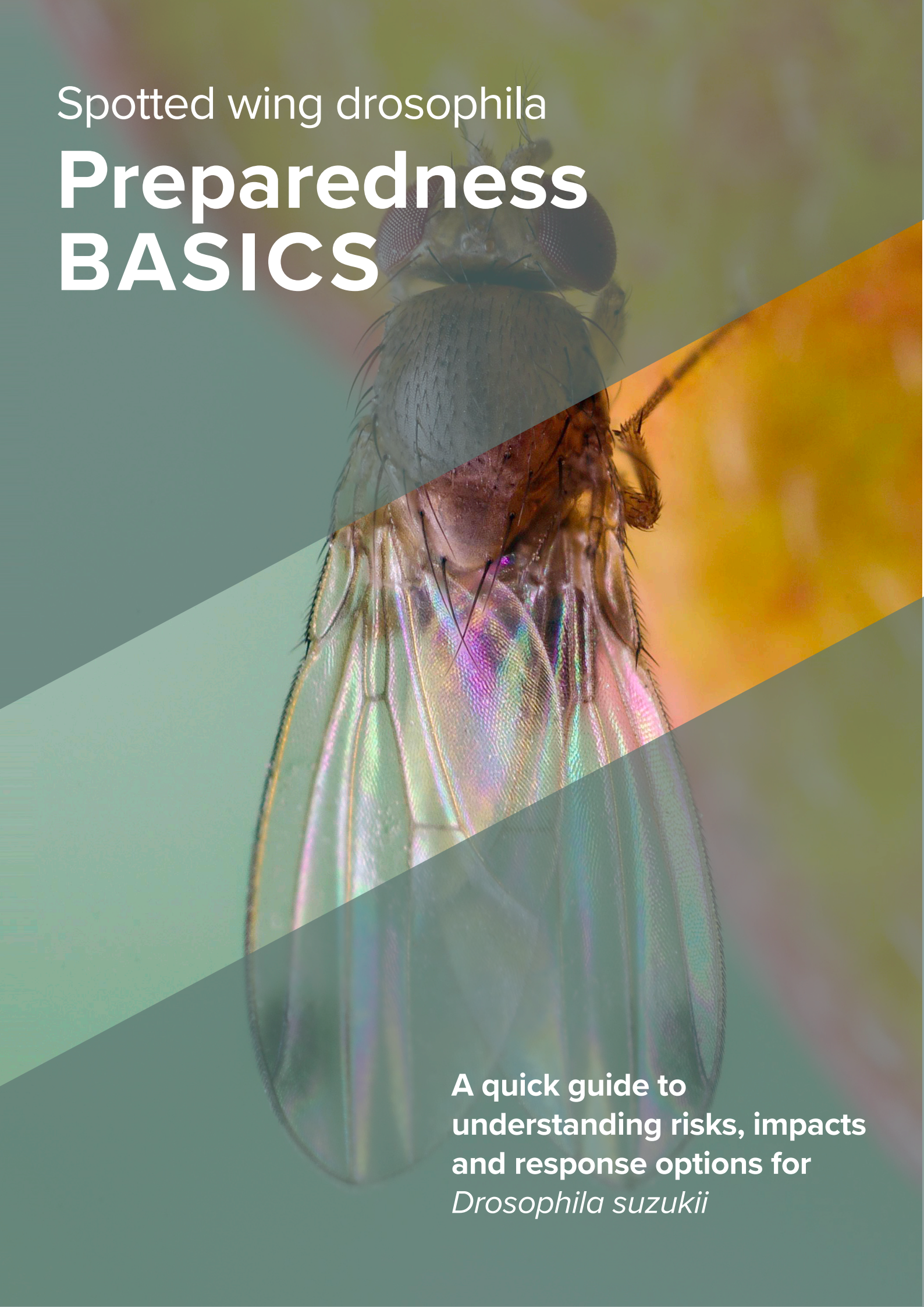
Spotted wing drosophila

Preparedness BASICS



A quick guide to understanding risks, impacts and response options for *Drosophila suzukii*

Preface

Spotted wing drosophila (*Drosophila suzukii*; SWD) is not found in Australia. However, as an exotic pest that has spread to many countries overseas it poses a serious threat to Australian fruit industries. In Australia it has been identified as a high priority exotic pest of the apple and pear, strawberry, blueberry, *Rubus* sp., cherry, dried fruit, summerfruit, table grape and wine grape industries.

Unlike most *Drosophila* species, females have the ability to infest ripening fruit. As a result, an infestation leads to impacts on fruit quality and yield. An outbreak and establishment in Australia would lead to significant pest management challenges for fruit orchards, and would require steps to be taken to limit spread through movement of host fruit.

In 2018, Hort Innovation initiated project MT17005 '*Improving the biosecurity preparedness of Australian horticulture for the exotic spotted wing drosophila (Drosophila suzukii)*'. This project was a collaboration between Plant Health Australia, **cesar**, Plant & Food Research, and Horticulture New Zealand. From May 2018 until June 2020 the project team investigated a range of topics to increase our understanding of how SWD could be detected early, contained and monitored if there were an incursion in Australia or New Zealand.

This project resulted in the development of several key outputs, including a spotted wing drosophila preparedness report, which incorporates project findings. The preparedness report was developed to aid government and industry biosecurity professionals in preparing and executing spotted wing drosophila incursion response activities and to support a transition from eradication or containment to a management scenario if needed.

SWD Preparedness Basics includes need-to-know information about this pest for government and industry biosecurity professionals and acts as your introduction to SWD and as an entry point to the preparedness report. Use it to quickly become acquainted with spotted wing drosophila during or prior to an incursion, and as a roadmap to using the preparedness report efficiently.

Preparedness Report

The spotted wing drosophila preparedness report is a detailed document that aggregates the latest knowledge about spotted wing drosophila for Australian government and industry biosecurity personnel.

Look up the preparedness report to learn more about spotted wing drosophila

Improving the biosecurity preparedness of Australian horticulture for the exotic spotted wing drosophila (2020). Plant Health Australia, Canberra, ACT. Hort Innovation project MT17005

This spotted wing drosophila Preparedness Basics guide contains extracted information from the preparedness report. It gives you the basics, while the preparedness report takes a deep dive into spotted wing drosophila research and current knowledge to assist in determining the requirements for an initial response to a detection as well as management of this species in Australia.

In this guide, references to the preparedness report are made to aid fast navigation of that document.

Keep an eye out for these signposts, which indicate where you can find more information in the preparedness report.

Refer to Preparedness Plan section 2

Pest details

Drosophila suzukii (Matsumura) is a member of the Diptera (fly) family. Like other flies, SWD is characterised by four distinct life stages: egg, larva, pupa, and adult. Immature life stages of most *Drosophila* species feed on fungi or decaying plant tissue. Spotted wing drosophila is markedly different due to a preference for laying its eggs in fruits that are not yet ripe, and for feeding of its larvae on the tissue of fresh fruit.

Lifecycle: In laboratory trials, this species has been shown to survive between 30-179 days, however, the life span of adults in the field is uncertain. After eclosion (emergence from the pupal case), adults typically become sexually mature in 1-2 days. A female can oviposit 7-16 eggs per day with several hundred eggs laid during her life. The average number of eggs laid by a female over the first four weeks of oviposition ranges from 85-148 eggs.

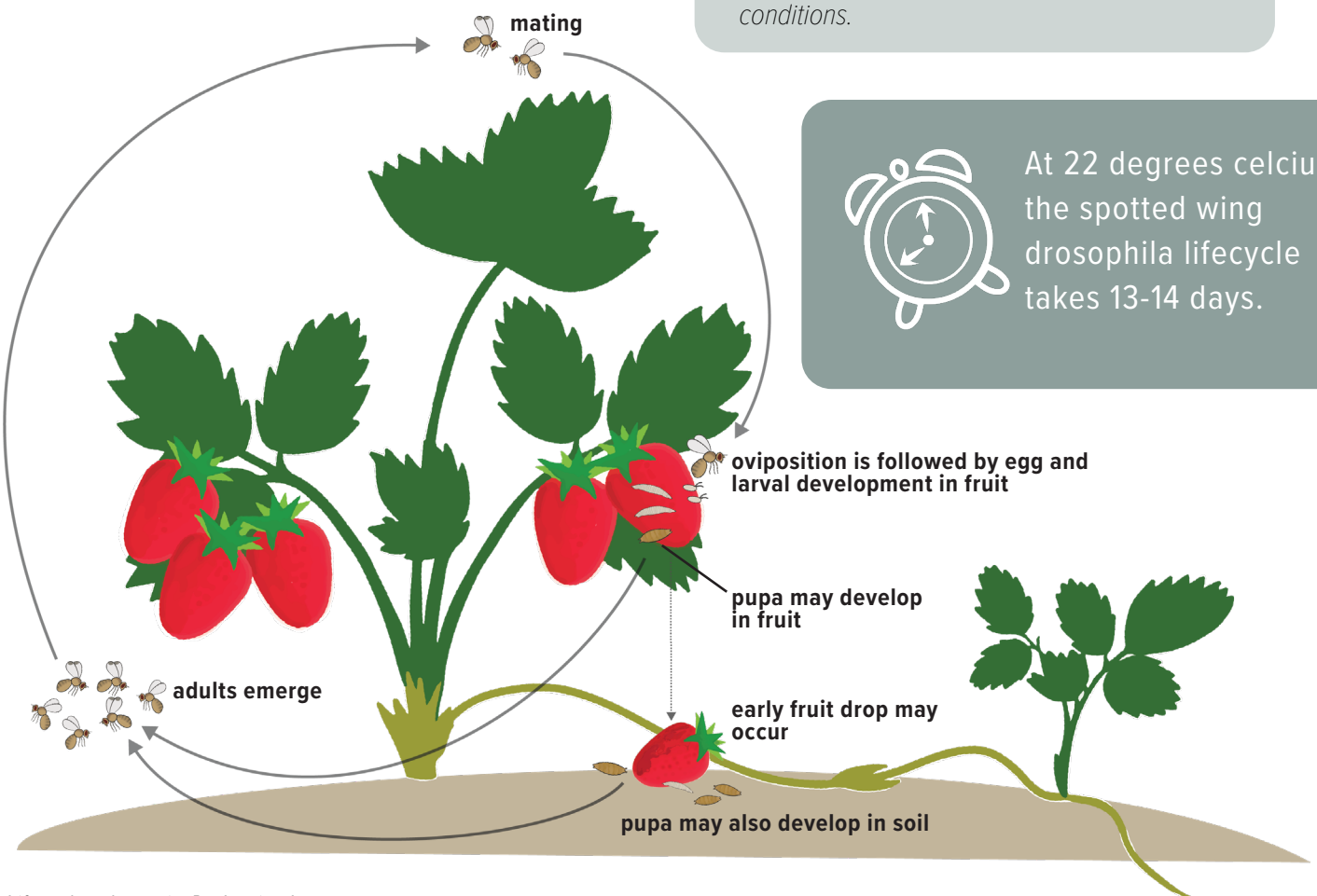
Sexually mature females enter reproductive diapause when the photoperiod is less than 14 hours at moderate temperatures (15 or 20 °C). At temperatures less than 10°C it will enter this diapause regardless of photoperiod.

Host type as well as environmental factors, such as temperature, influences the number of eggs laid. Eggs, larvae and pupae vary in developmental time depending on environmental conditions, with warm conditions leading to the shortest development times. At 22°C, the egg stage takes approximately 1.4 days, the larval stage takes 6 days, and the pupal stage takes 6 days. Therefore, under mild conditions it will take 13-14 days for this fly to develop from egg to adult. A short development time allows the fly to complete several generations across one growing season.

Once hatched larvae feed on the fruit as they develop through three instars (growth stages). If the fruit has dropped to the ground, third instar larvae will move into the soil and pupate. If fruit is still on the branch, larvae will often drop and pupate in the soil rather than remain in the fruit.

What is 'reproductive diapause'?

This is a period when physiological processes involved in reproduction are stopped or slowed down, usually due to challenging environmental conditions.



At 22 degrees celcius the spotted wing drosophila lifecycle takes 13-14 days.

Lifecycle schematic: Dr Jessica Lye, **cesar**

Common name	Spotted wing drosophila
Scientific name	*Drosophila suzukii* (Matsumura, 1931)
Synonyms	*Leucophenga suzukii* (Matsumura, 1931)
Taxonomic position	Class: Insecta Order: Diptera Family: Drosophilidae Genus: *Drosophila* Sub genus: *Sophophora*

Spotted wing drosophila adults hover around a blackberry - a preferred host for feeding and oviposition.

Refer to Preparedness Report section 2.2 for a detailed host list.

Hosts: While much of the focus on spotted wing drosophila is related to its status as a serious pest of soft and thin-skinned fruits, there is evidence that this it has a wide host range. Various soft fruited crops including figs, summerfruit (apricots, nectarines, plums, peaches), cherries, strawberries, *Rubus* sp. berries (raspberries, blackberries and related crops), *Ribes* sp. berries (currents, gooseberries, etc.), blueberries, and grapes have been identified as hosts. Other thicker-skinned fruit such as citrus and pome fruit (apples and pears, kiwifruit etc.) can also act as hosts when the fruit is damaged.

In the event of an incursion, the wide host range, including many wild and ornamentally cultivated plants, would provide significant habitat for this pest in Australia outside of managed crops.

Signs and symptoms: SWD larvae cause damage by feeding on the pulp inside fruit and berries. Infested fruit show small scars and indented soft spots on the surface, which is a result of oviposition. Infested fruit can collapse around the larval feeding site causing a depression or blemish on the fruit and sap exudates may also be evident. The oviposition scar exposes the fruit to secondary attack by pathogens and other insects. If a spotted wing drosophila infestation is high, the entire fruit can collapse. Signs of infestation may be confused with normal ageing of mature fruit. However, fruit infested with SWD show rapid softening and wrinkling within a few days after egg laying. Signs and symptoms of SWD may be delayed if fruit is cold stored, with symptoms of fruit collapse developing rapidly when fruit is brought out of cold storage.

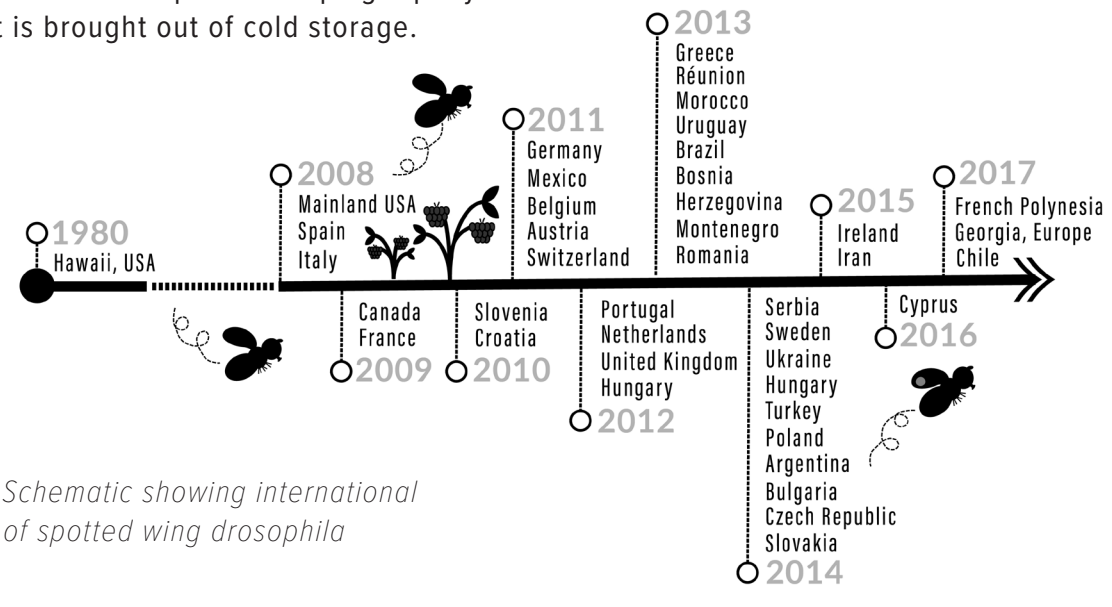
Diagnostic considerations: Adult SWD are small flies 2-3 mm in length with a wingspan of 6-8 mm. They have prominent red eyes and are pale brown or yellow-brown in colour and have dark abdominal bands. The males are generally smaller than females and have a dark spot on the end of each wing. The females can be distinguished under a microscope from other *Drosophila* species by the presence of a double serrated ovipositor.

The pupae are 1 mm wide, 2-3 mm long and red to brown in colour. They are oval shaped and have a pair of distinctive horn shaped protrusions (respiratory organs), which divide into branches at one end and a small v-shaped structure at the other (also for respiration).

Larvae are cream to white maggots, approximately 3 mm in length. Eggs are white, oval shaped, 0.6 mm in length and have two filaments at one end for respiration, which sometimes protrude from fruit after oviposition.

Superficially spotted wing drosophila is very similar to some endemic insects, with several similar *Drosophila* species common in rotten fruit in Australia. As a result, identification based on morphology of the pest will be challenging for most people.

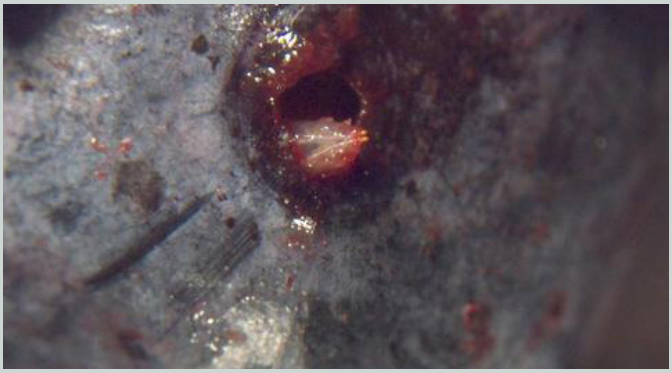
Geographic distribution: The native geographical range of spotted wing drosophila is thought to include ten countries across south-east Asia, ranging from Japan to Pakistan. Over the past decade it has spread to North America, South America and Europe.

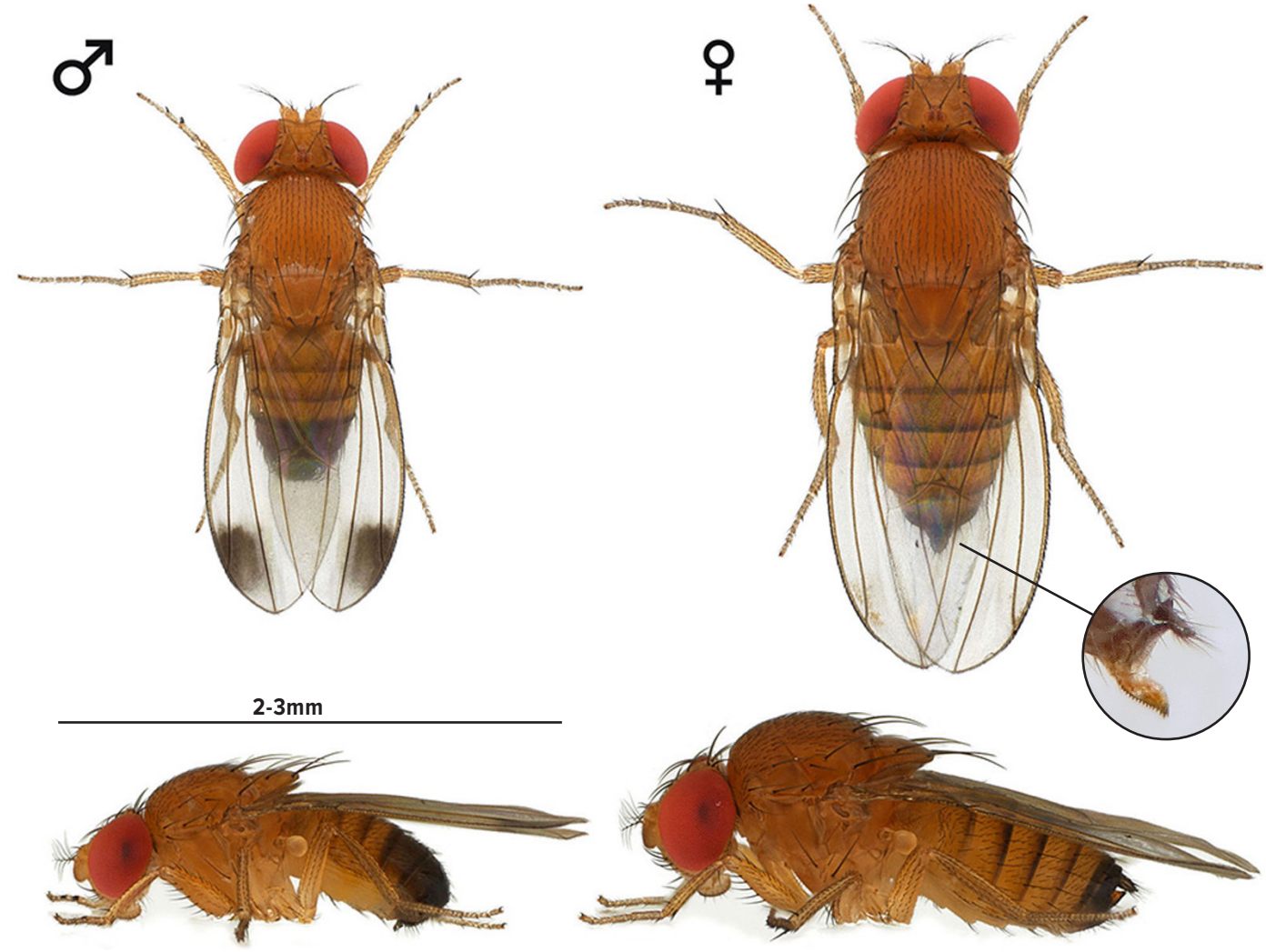


Above: Schematic showing international spread of spotted wing drosophila

Eggs, larvae and pupae can only be differentiated from closely related *Drosophila* species using molecular methods, or by rearing them into adults.

Top right: Eggs oviposited in strawberry (Hannah Burrack, North Carolina State University, Bugwood.org). Bottom right: Depression in cherry resulting from larval feeding (Oregon Dept Ag - Amy Dreves - Flickr SWD blackberry NonCommercial-NoDerivs 2.0 Generic CC BY-NC-ND 2.0). Bottom left: Larva feeding on blueberry (Frank Hale, University of Tennessee, Bugwood.Org)





Above: Spotted wing drosophila adult male (left) and female (right), dorsal and lateral views. The female serrated ovipositor is shown (circle).

Photos of adults: AgriScope [adapted], flickr.com, used under licence NonCommercial-NoDerivs 2.0 Generic CC BY-NC-ND

Photo of ovipositor: Martin Cooper [adapted], flickr.com, used under licence NonCommercial-NoDerivs 2.0 Generic CC BY-NC-ND

Spotted wing drosophila larvae feeding on wineberry.

Refer to Preparedness Report section 2.4 for detailed diagnostic information.

Refer to Preparedness Report section 3

Risk pathways

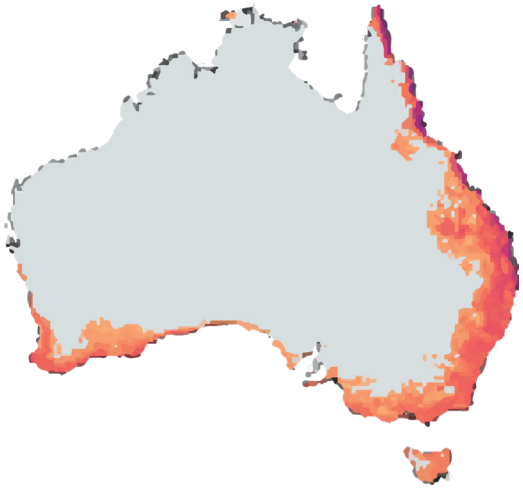
Overall it has been determined that the likelyhood of spotted wing drosophila being transported to to Australia is low due to:

- current import and phytosanitary restrictions on exporters of high-risk commodities;
- small volumes of imported fresh fruit due to limited demand;
- requirements for declaration of any plant-derived goods associated with passenger movements and mail; and
- the low likelihood of natural spread (flight) to Australia.

To further minimise risk of an incursion it is necessary to prioritise surveillance activities, based on where this pest is most likely to enter and establish.

Research group, **cesar**, have modelled establishment and spread potential of spotted wing drosophila in Australia. According to this work, a large portion of Australia's southern and eastern coastal fringe, as well as some areas in western Australia are predicted to have climates that will support establishment.

One of the most concerning attributes of SWD as a plant pest is its ability to invade a region quickly. This is largely due to high reproductive rates, relatively long life, a broad host range, and the capacity to survive in both cool and warm areas. In the absence of control activities it is predicted that the fly would fill its ecological niche in climatically suitable regions within six years of an incursion.



Above: Predicted establishment of spotted wing drosophila if the pest were to enter Australia and successfully spread. Darker colours indicate higher establishment potential. Source: Dr James Maino, **cesar**

Refer to Preparedness Report sections 3.2 and 3.3 for more information on predicted spread and establishment.

Steps to entry

For a spotted wing drosophila incursion to occur via infested fresh fruit a number of steps must take place:

1. **Infestation of fruit in currently infested range**
2. **Survival of post-harvest processes**
3. **Survival during transport**
4. **Transport to a new region or country**
5. **Development to adulthood (for immature lifestages)**
6. **Exposure to a suitable host**
7. **Finding a mate (unless a mated female adult enters)**
8. **Finding a suitable host for oviposition**

Refer to Preparedness Report section 3

Economic impact

Worldwide, the economic impact of this pest on horticultural industries has been significant. The magnitude of economic damage associated with spotted wing drosophila can in part be attributed to its ability to oviposit in, and feed on, ripening and fresh fruit. Financial loss can be incurred from:

- direct yield loss;
- reductions in saleable fruit;
- increased management costs (planning, trapping, infrastructure, chemicals and labour);
- disruption to current IPM plans for other pests;
- post-harvest sorting costs;
- quality downgrades;
- reduced marketability of fruit with no practical option for treating infested commodities or redirecting them to alternative markets; and
- potential market access control measures.

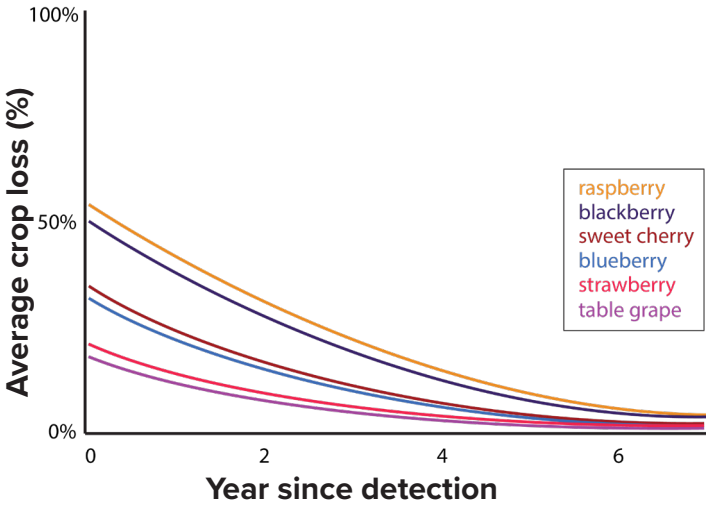
Based on international reports of crop losses variation in yield impact is associated with the crop type and time passed since spotted wing drosophila establishment in the region.

The association with crop type is likely to reflect intrinsic factors such as permeability of fruit skin or frost susceptibility, while the negative association with year since establishment likely reflects improvements in practices for managing the pest.

The economic impact potential of spotted wing drosophila to Australian horticulture has been investigated through development of a simulation framework by **cesar** that takes into account predicted spread, establishment and the locations of major host crop production regions.

The accumulated economic impact of spotted wing drosophila in Australia was predicted to be substantial at AUD195-257 million, with most of the impact arising from southern soft fruit growing regions. Simulating the incursion scenario using a variety of starting locations, such as Adelaide, Devonport, Cairns and Mildura resulted in little variation in accumulated economic impact six years post-incursion.

Refer to Preparedness Report section 3.4 for a detailed table of yield loss reported overseas.



Common name	Proportion reported yield loss			Number of reports
	Average	Min	Max	
Blueberry	14%	0	100%	56
Raspberry	**31%**	0	100%	52
Blackberry	24%	0	100%	45
Sweet cherry	17%	0	90%	17
Strawberry	8%	0	80%	45
Table grape	7%	0	35%	23

Above: Impact potential of spotted wing drosophila per crop based on international reports of yield loss due to infestation. The graph (left) is a schematic representation of reported yield loss over time since spotted wing drosophila detection, based on reports from the United States. The table (right) includes reported losses for those crops where the highest number of reports were available. The highest average yield impact is bolded. Source: Dr James Maino, **cesar**

Traps to monitor for spotted wing drosophila hang from a *Prunus* sp.

Research has shown that red is an attractive colour for this pest.

Refer to Preparedness Report section 4.1 for a summary of commonly used handmade and commercial traps for SWD.

Refer to Preparedness Report section 4

Planning surveys

Because spotted wing drosophila has not been reported as a severe insect pest of fruit in its native region, no effective monitoring tools were available prior to its invasion of North America and Europe in the late 2000s. To date there have been two major avenues that have led to early detection in incursion examples from around the world:

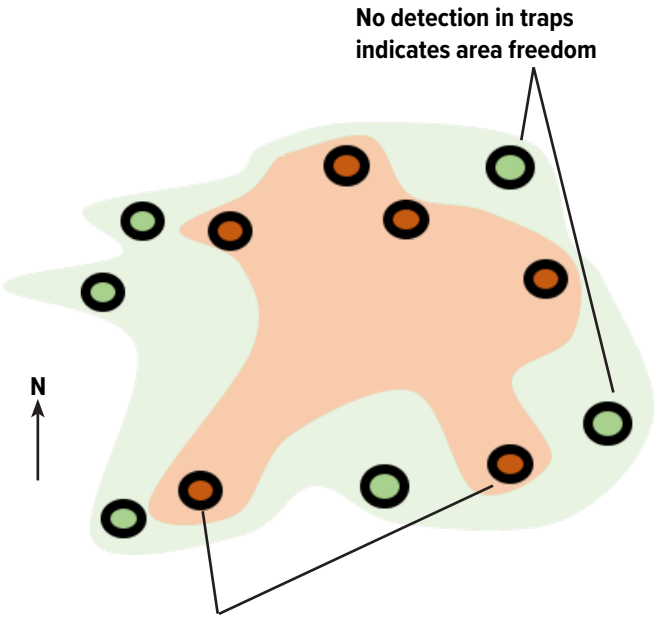
- targeted trapping; and
- reporting of crop damage.

A range of traps (malaise, bottle and tephri traps) baited with a variety of attractants (beer, wine, fruit, apple cider vinegar or a combination) have resulted in early detections. Since those early incursions improved attractants have continued to be developed.

In the event of a detection of spotted wing drosophila delimiting surveys will be required to determine the extent of the outbreak. These surveys will ensure that areas free of the pest retain market access and areas with the pest can put in place effective controls.

What is a 'delimiting survey'?

This is a survey conducted to establish the boundaries of an area considered to be infested by or free from a pest. The original detection location is used as a starting point to determine how the pest arrived and to where it may have spread (International Plant Protection Convention).



When planning surveillance in Australia, climatic suitability, land use, host availability, season, high risk points of entry, origin of fruit imports, and fruit transit and disposal must be taken into account.

Surveillance priorities for detection and delimiting spotted wing drosophila should consider:

- Trap catches do not reflect population density and experience overseas has shown that any level of trap capture may be indicative of a high population in the surrounding area.
- Larval extraction using sugar or salt flotation testing is a good indicator of the actual threat to crops.
- Crops, wilderness areas and urban environments are all possible detection sites (in Australia wild blackberry is a major weed could play a strong role in supporting populations).
- Landscape level factors, such as seasonal movement between hosts or between differing altitudes should be taken into consideration.
- The first trap captures in Europe generally occurred in July-October and increase over the season. The southern hemisphere equivalent to this first trap capture period is January-March. However, detection year-round may be possible in parts of Australia that have a similar climate to that of the United Kingdom (where SWD is trapped throughout the year).
- Common trap-and-lure systems designed for spotted wing drosophila show inconsistent performance.
- Often ripening fruits are more attractive than traps and lures.
- The surrounding landscape will play an important role in determining likely crop infestation dates, with recent overseas research drawing a link between proximity of woodland refuges and early infestation of fruit.

Surveillance should involve:

- visual inspection in high risk areas (e.g. edges of crops or orchards with mature fruit or vegetables);
- trapping with two forms of lure (e.g. a yeast-based lure and a wine/ apple cider vinegar-based lure); and
- fruit sampling via flotation testing using sugar water.

The type of sites where spotted wing drosophila is likely to first arrive are difficult to determine from overseas incursions, as the first site of detection is not necessarily the invasion epicenter. However, below are some considerations when planning early detection surveys:

- The most important pathway into Australia will likely be through fruit that is imported and then on-sold to consumers. Therefore, urban areas are likely to be where spotted wing drosophila populations will first occur.
- The invasion site and the 'spreading centre' of an invasive species are not always one and the same. The first invasion site is not always suitable for fast spread. This means that the spreading centre may stem from a secondary invasion site rather than the initial arrival point.
- Areas where fruit are collected, stored or particularly where waste fruit are dumped should be a focus of surveillance.
- The location of high throughput ports or airports are important to consider. This particularly includes ports that are high volume entry sites for fresh fruit imported from countries where spotted wing drosophila is present.
- Fruit distributors, wholesalers and retailers would be important to note as disposal of unsold imported fruit via wholesaler or retailer cull piles may present a risk.

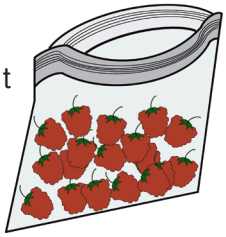
The following is recommended for delimiting surveillance:

- Take into account tracing information to determine potential pathways for movement of material into and from the site of the initial detection.
- At each trapping site chose a crop that is a preferred host plant of spotted wing drosophila. It is also important to have traps in wild vegetation surrounding the crop.
- If suspicious damage is detected, fruit samples should be collected and traps should be placed around the affected area in an attempt to capture adults and diagnose the pest responsible for the damage.
- If spotted wing drosophila are confirmed, visual surveillance supported by trapping should be used to monitor the edges of the outbreak zone.
- Surveillance should be accompanied with awareness material, signs and personal visits to households and businesses within the surveillance zone and buffer zones.
- Detection year-round may be possible in parts of Australia. Outside of production season trapping should occur within non-crop hosts.
- Deploy traps in time to capture adult spotted wing drosophila straight after winter diapause.

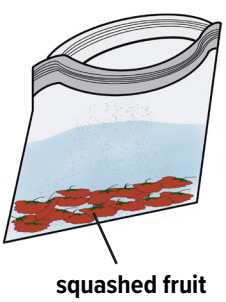
Refer to Preparedness Report sections 4.2 and 4.3 for more information on detection and delimiting considerations.

Do you know how to conduct the sugar flotation test?

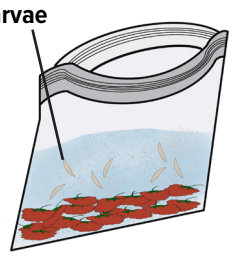
1. Collect fruit and add 100g to a sealable bag.



2. Lightly crush fruit and add sugar solution (150g sugar:1L water).



3. Leave for 30 minutes. Larvae will move out of the fruit and can be collected for diagnostic analysis.



Refer to Preparedness Report section 5

Options following detection

Eradication: Eradication potential will likely be low and will require very early detection during an invasion, and rapid host plant movement controls.

No country has eradicated spotted wing drosophila and it appears to spread very rapidly after initial detection. This is likely to be a result of several factors:

- The apparent rapid spread between regions and countries could be an artefact of the response post detection. Following an initial detection, increased awareness and surveillance occurs, which identifies and delimits populations that are already well established.
- The ability of spotted wing drosophila to spread long distances through human assisted movement is exacerbated by its cryptic nature (small eggs and larvae sheltered in fruit and superficial similarity to other *Drosophila* species). Therefore, it could go undetected for a long period of time.
- Spotted wing drosophila is highly fecund and has a wide host range, both in crops under commercial production as well as wild non-crop hosts.

While a range of synthetic lures are now available, they have been developed to assist management of the pest overseas, and their efficacy in supporting an eradication response is untested.

Management: Overseas spotted wing drosophila is managed using a highly integrated approach using chemical and non-chemical control tactics. Within Australia, the wide climatic zones spanned by berry, cherry, grape, and summerfruit growing regions will require management planning that takes into account local conditions.

Making production sites less favourable for spoted wing drosophila through cultural controls, and regular monitoring (visual crop inspections, trapping with lures, and fruit sampling) are of particular importance. In the case of an incursion chemical options would be quickly made available to Australian growers through the minor use and emergency permit system (and possibly through product registrations).

However, chemical applications do have limits on how useful they are for spotted wing drosophila control. Foliar sprays must be timed to target adult populations, thus monitoring is crucial. Eggs and larvae are difficult to control because they are protected inside the fruit. Many chemical products are non-specific and can impact on beneficial species, disrupting Integrated Pest Management programs and leading to pest flare. Limited chemical options and regular application of the same Mode of Action also increases resistance risk.

Refer to Preparedness Report section 5

Awareness raising

Early detection of spotted wing drosophila will be important to ensuring that growers can execute effective management plans quickly. To achieve this, pro-actively raising the level of knowledge about this exotic pest within affected industries is of key importance. Raising industry preparedness at a regional level may use tactics outlined in the Improving Local Preparedness checklist below.

A key message that should be included in any communication is '*Protecting Australia from spotted wing drosophila will require an industry-wide approach. If you see anything unusual call the Exotic Plant Pest Hotline on 1800 084 881.*'
In the event of a spotted wing drosophila incursion clear messages about identification, impact and control will be important for facilitating an effective response or a transition to management.

Contents of Spotted Wing Drosophila Preparedness Basics may be used as a reliable reference when developing communications intended to raise awareness about spotted wing drosophila. If content is used in development of awareness material please include attributions as outlined in this document.

Resources

The Emergency Plant Pest Response Deed (EPPRD) and PLANTPLAN should be referred to, in conjunction with the spotted wing drosophila preparedness report. The EPPRD covers the management and funding of responses to Emergency Plant Pest incidents, including the potential for Owner Reimbursement Costs for growers. It also formalises the role of plant industry participation in decision making, as well as the contribution of affected industries towards the costs of executing national exotic pest responses.

Underpinning the EPPRD is PLANTPLAN, the agreed technical response plan for an Emergency Plant Pest incident. It provides nationally consistent guidelines for response procedures, outlining the phases of an incursion, as well as the key roles and responsibilities of industry and government during each of the phases.

Refer to planthealthaustralia.com.au for further details.

Improving local preparedness

- ✓ Ensure key staff members in your organisation are familiar with SWD Preparedness Basics.
- ✓ Circulate the **cesar** SWD PestBites identification video and SWD PestCase videos found at youtube.com/cesaraustralia.
- ✓ Circulate the Plant Health Australia SWD fact sheet.
- ✓ Encourage local host crop farms to source pre-emptive advice from your State Biosecurity Authority.
- ✓ Conduct local training in procedures for logging details of an infested site, containment of the site, taking a fruit sample and making a report.
- ✓ Identify potential local SWD pathway risks.
- ✓ Use Industry Biosecurity Plans to decide on actions to minimise local pathway risks.
- ✓ Support farm managers in biosecurity plan development.
- ✓ Add SWD as an agenda item for discussion at your next grower group meeting.
- ✓ Take Plant Health Australia's online biosecurity (BOLT) training.
- ✓ Set up a local working group that can be 'activated' to act as an information source and trusted communicator during an incursion.

Attributions

Content in SWD Preparedness Basics has been drawn from the SWD preparedness report, a product of project MT17005. The lead author of the SWD preparedness report is Dr Daniela Carnovale, Plant Health Australia, with input from the project team and the SWD Steering Group. SWD Preparedness Basics was developed by Dr Jessica Lye, **cesar**.

This guide should be referenced as:
Spotted Wing Drosophila Preparedness Basics (2020) Hort Innovation project MT17005 'Improving the biosecurity preparedness of Australian horticulture for the exotic Spotted Wing Drosophila *(Drosophila suzukii)*'

This content was developed as a part of MT17005 'Improving the biosecurity preparedness of Australian horticulture for the exotic Spotted Wing Drosophila (*Drosophila suzukii*)', which was funded by Hort Innovation, using the strawberry, raspberry and blackberry, cherry and summerfruit 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. Project partners were Plant Health Australia, cesar, Plant & Food Research, and Horticulture New Zealand. In-kind support was provided by B3.

Personel involved in the MT17005 project: Dr Sharyn Taylor (Project lead, Plant Health Australia), Dr Daniela Carnovale (Plant Health Australia), Dr Darryl Barbour, Dr James Maino (**cesar**), Dr Jessica Lye (**cesar**), Raf Schouten (**cesar**), Dr Lloyd Stringer (Plant & Food Research), Dr David Bellamy (Plant & Food Research), Mark Bullians (Plant & Food Research), Dr Anna Rathe (HortNZ). The Hort Innovation project manager was Dr Penny Measham.

MT17005 research reports developed thorughout the project, as well as a variety of outreach materials, can be accessed by contacting Hort Innovation.

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