NSW DEPARTMENT OF
PRIMARY INDUSTRIES

Readers' Note

Fruit fly (Queensland and Mediterranean)

Bactrocera tryoni **(Queensland fruit fly)**
Ceratitis capitata **(Mediterranean fruit fly)**

IPDM quick facts

Sample unit: *Trap*

When to monitor: *Late blossom to harvest*

How often: *Every 3 or 4 days*

Action level: *20 flies per trap*

Sample unit: *Fruit*

When to monitor: *Mid-season to harvest*

How often: *Every 3 or 4 days*

Action level: *Stung fruit*

Take extra care when monitoring:

- ***Rainfall and a drop in temperature lead to an increase in fruit fly activity.***
- ***Hot and dry weather keeps the numbers of flies low.***

The pests and their damage

There are two species of economically important fruit flies in Australia. Queensland fruit fly (*Bactrocera tryoni*) is native to Australia and can be found in parts of the Northern Territory, Queensland, New South Wales and the eastern corner of Victoria. Mediterranean fruit fly (*Ceratitis capitata*) is one of the world's most destructive agricultural pests and was introduced to Australia and first recorded in 1895. Although it is currently restricted to South West Western Australia, it poses a serious incursion threat to other States, particularly South Australia.

Adult Mediterranean fruit flies are 3 to 5 mm long. The thorax (back) is mottled, with shiny, dull black and yellowish-white areas. The abdomen is yellowish to brown with two pale cross bands. The wings are patterned, with yellow, brown and black spots and bands.

Adult Queensland fruit flies are about 7 mm long, and reddish brown with yellow markings.

Fruit flies lay their eggs in maturing and ripe fruit. Larvae (maggots) hatch from these eggs, and the fruit is usually destroyed within days by their feeding and the associated rotting.

A serious regional issue during the last 10 years in:

- Alstonville
- Manjimup/Donnybrook
- South Queensland
- Granite Belt
- Perth Hills

Queensland fruit fly

Mediterranean fruit fly

Fruit fly larvae

Rotting fruit following fruit fly infestation

Prevention

Exclusion zones, quarantine and restrictions on movement

The Fruit Fly Exclusion Zone (FFEZ).
The Commonwealth Government and the governments of South Australia, Victoria and New South Wales have collaborated to form the FFEZ. The FFEZ covers key production areas, including the Riverlands, Sunraysia, Mid Murray, Goulburn Valley and Murrumbidgee Irrigation Area.

Queensland fruit fly is excluded from this area, so that fruit fly sensitive markets within Australia and export markets can remain open. Import of fresh fruit to this area is not allowed. Roadside signs and road blocks have been set up to enforce this ban.

Regular monitoring is carried out within the FFEZ to ensure that outbreaks are controlled quickly.

Interstate restrictions on movement.
Movement of fruit and other hosts of fruit fly is restricted in all summerfruit-growing States. Details for each State are provided by State government departments of agriculture at their websites (page 133). A quick reference to restrictions on fruit movement can be obtained by looking at the 'Travellers' Guide to Interstate Quarantine' at

http://www.affa.gov.au/corporate_docs/publications/pdf/quarantine/pr/reader.pdf

Remove alternative breeding and feeding sites

Remove unwanted fruit trees from around sheds and houses and along boundary fences and irrigation channels. Practise good packing shed hygiene, with thorough inspection to remove any infested fruit. Properly dispose of reject fruit by burning, boiling, or soaking in water with a surface layer of kerosene for 3 days. Do not bury fruit, as fruit flies have a soil-inhabiting phase in

Fines are imposed for illegal transport of fruit.

Remove fallen fruit from the orchard, as it provides an alternative breeding site for fruit flies.

their life cycle and burial will help them survive. Remove all late-hanging and fallen fruit missed during harvest.

Pruning

Keep the orchard canopy open for better spray penetration.

Monitoring

Government monitoring of exclusion zones

State government departments of primary industries or agriculture carry out regular, rigorous monitoring to ensure that incursions of exotic fruit flies are detected quickly. Examples of these programs can be found on the websites of all State government departments of primary industries.

Monitoring by orchardists

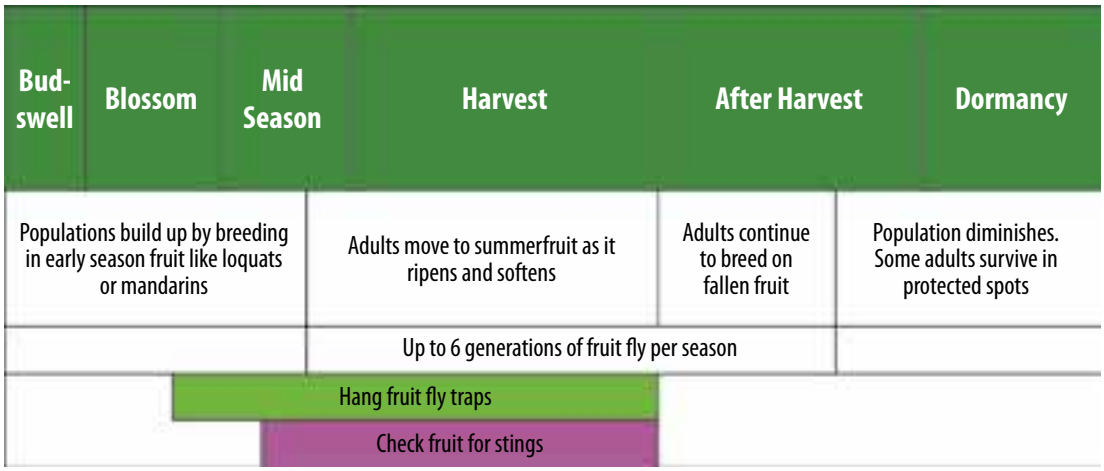
Monitoring in your orchard will allow you to detect fruit flies early and take appropriate action before too much damage is done. It also increases the number of control options available to you (see charts at top of page overleaf).

Hang fruit fly traps

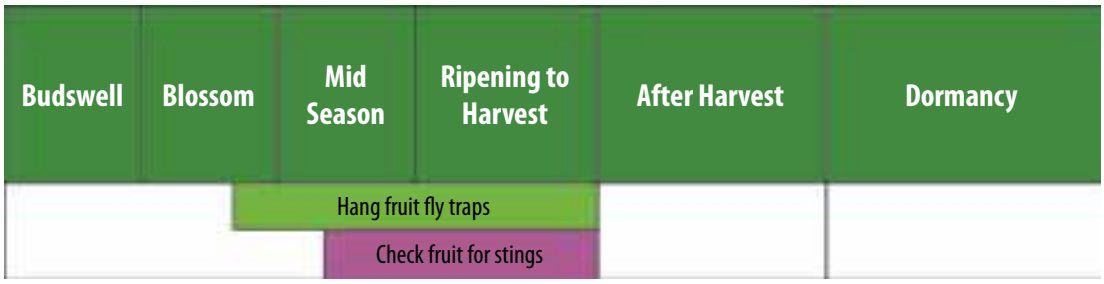
Trapping in the orchard allows orchardists to monitor fruit fly numbers and control them early. The most common type of trap used in Australian orchards is the Lynfield lure trap. Traps are commercially available from rural suppliers in fruit fly-prone areas. Traps attract only the male fly and therefore do not give an accurate indication of female fly activity. This is a

A Lynfield fruit fly trap

Coastal and low-chill fruit monitoring



Monitoring in other regions



major limitation of this monitoring technique, as females are responsible for fruit damage through egg laying and subsequent maggot infestation.

There are two types of synthetic lures commonly used:

- **Capilure:** a pink, aromatic liquid used for Mediterranean fruit fly
- **Cuelure:** a lemon-coloured liquid used for Queensland fruit fly.

These lures must not be mixed or allowed to contact your hands or the trap body, otherwise their attraction to different fly species is affected. This could lead to non-target fruit flies being caught and make identification difficult.

Traps should be hung in the tree canopy at about head height and two-thirds of the way out from the trunk. The trap should be in semi-shade and well clear of foliage. This allows easy access for the flies through the entry hole of the trap.

Hang fruit fly traps at around late blossom. Hang one trap in the centre of each large block. In regions with high fruit fly pressure (South East Queensland, Northern New South Wales, South East Western Australia) check traps every 3 or 4 days as the fruit softens, and count the male fruit flies. Empty the traps after counting.

It is also a good idea to check fruit and leaves visually for fruit fly at this stage.

Check fruit for stings

Around the middle of the season fruit should be monitored for stings. Eggs are often laid up to 8 weeks before the fruit is mature. The sting sites on fruit may show as discoloured (sometimes prematurely coloured), often blackish spots that may exude filaments or blobs of clear gum. If you're unsure, cut through the tentative sting with a very sharp knife or razor blade and inspect it with a hand lens. You should be able to see fly eggs.

Appropriate action

Following detection in orchards outside exclusion zones (see chart on page 48).

Bait sprays

Bait spraying is a good alternative to orchard cover sprays in areas where fruit fly pressure is low. Once monitoring indicates that fruit fly is present in the orchard, start the baiting program and continue this every 7 to 10 days until the harvest is completed.

In endemic areas, at least eight bait applications are recommended for all fruit trees 3 years and older:

- spring (September to October): four or more bait sprays at 7-day intervals

- autumn (March to April): four to eight baits at 7-day intervals.

Baits are prepared using a protein source and an insecticide (chlorpyrifos, maldison or trichlorfon). Both males and females are attracted to the protein. As they feed they are killed by the insecticide.

Observe the mixing and safety directions on pesticide labels. To make 100 L of bait spray based on maldison, take:

- 435 mL maldison (1150 g ai/ L), plus
- 2 L yeast autolysate 50% or Natflav 500.

Add the protein lure (yeast autolysate or Natflav 500) to 75 L of water. Mix thoroughly, add the maldison and top up to 100 L with water. The bait mix can also be prepared using maldison (500 g ai/ L), as follows:

- 2.5 L maldison (500 g ai/L), plus
- 2 L yeast autolysate 50% or Natflav 500
- 100 L of water.

An alternative bait for summerfruit can be made using chlorpyrifos wettable granules or wettable powder (Lorsban™ 750WG or Pyrinex 500 WP). A trichlorfon-based bait can be made from Dipterex® 500 SL. Directions for bait preparation are given on product labels.

In low-density plantings, about 100 mL of the prepared bait should be applied to the foliage of every second tree in every second row. For higher-density plantings, apply bait to every fourth tree in every second row. Use 30 L of the mixture per hectare of orchard.

Baiting is more effective when carried out in the morning, when fruit flies are most active. It is important to avoid direct contact between the bait and the fruit, as the protein may induce phytotoxic damage to some fruit.

Killer pads or male annihilation blocks

In towns it is possible to use an 'attract-and-kill' technique for male fruit flies. Killer pads have Cuelure (for Queensland fruit fly) as the male fly attractant and maldison as the killing agent, impregnated in a block about 5 cm × 5 cm made from low-density particle board (Caneite®) or material such as felt or cardboard. The pads are nailed to trees in the orchard at a density of between 10 and 30 per ha, depending on the fly pressure. For trade reasons this technique is prohibited inside the FFEZ. Further details are available from your State government department of primary industries.

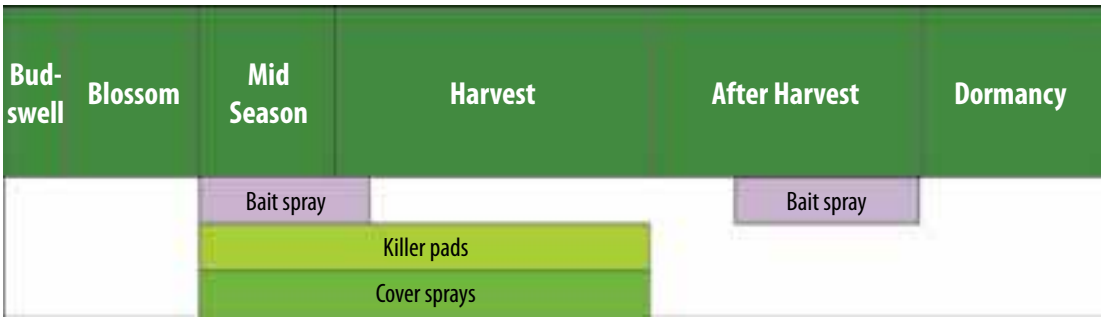
Cover sprays

Where possible, avoid using cover sprays. Spraying with the broad-spectrum insecticides registered for fruit fly control often leads to destruction of the populations of predatory insects that naturally control other pests such as two-spotted mite.

However, bait spraying alone will not be enough to control high populations of fruit fly. Where Interstate Certification Assurance is required (see below) cover sprays are be the only alternative for control. Pre-harvest cover sprays of the trees

Correct hanging position for a fruit fly trap

Cross-section of a fruit fly sting site. Note the fruit fly eggs.



and fruit with insecticide kill the fruit flies that seek shelter in the tree canopy and kill any larvae in the fruit. Trees and foliage should be sprayed to leaf saturation (i.e. when spray droplets just begin to drip from the foliage). Do not pick fruit until the withholding period for the insecticide has expired. For best results make sure you achieve satisfactory spray coverage of the fruit. It's therefore essential that you use correctly calibrated spray equipment.

More information

Some of the information provided in these references comes from other countries (marked †). Always remember that the biology of pests and diseases and the tactics used to control them vary subtly from country to country and will change with time. Be particularly cautious with pesticide recommendations. If a pesticide is not recommended in this manual (page 137) you must check that it has current registration in your State and abide by the conditions of that registration, as specified on the pesticide's label. ALWAYS READ THE LABEL.

HAL projects: Summaries available on the web at www.horticulture.com.au/[.] Final reports can be ordered from Horticulture Australia Limited:

- AH01013: *Use of microsatellite tracking to determine the source of Qfly outbreaks in the Fruit Fly Exclusion Zone*
- AH01025: *Developing the sterile insect technique for eradication of incursions of Mediterranean fruit fly in Australia*
- AH00012: *Improved protein bait formulations for fruit fly control—revised year 3 proposal*

Interstate Certification Assurance: ICA-21 and ICA-23.

Summerfruit destined for interstate markets and originating from Queensland must undergo a prescriptive spray regime, regardless of monitoring. This summerfruit must have a program of cover-sprays consisting of a mixture of 75 mL of a concentrate containing 550 g/L fenthion per 100 L of spray mix. These sprays must be:

- applied to all summerfruit in all blocks in which summerfruit is grown for certification
- applied thoroughly to the fruit
- applied at intervals of
  —6, 4, 3, 2 and 1 weeks before harvest (low-chill summerfruit grown in coastal areas)
  —4, 3 and 2 weeks before harvest (other summerfruit varieties).

Post-harvest inspection. Fruit must be inspected after harvest and found to be free from broken skins and live fruit fly.

Full details of ICA-21 and certification requirements are available at:

www.dpi.qld.gov.au/extra/ica/procedures/ica/ica-21/ICA-21.pdf[.]

Fruit originating in Western Australia and destined for interstate markets is subject to ICA-23. Full details of ICA-23 and certification requirements are available at:

http://www.agric.wa.gov.au/pls/portal30/docs/FOLDER/IKMP/PW/Q/ICA23.pdf

Queensland

ICA-21: *Pre-harvest Treatment and Inspection of Stonefruit.* Full text version available at www.dpi.qld.gov.au/extra/ica/procedures/ica/ica-21/ICA-21.pdf

Queensland Department of Primary Industries and Fisheries (2001) *Exotic Plant Pests: Mediterranean Fruit Fly.* Available at the QDPIF website, www.dpi.qld.gov.au/

Queensland Department of Primary Industries and Fisheries (2001) *Exotic Plant Pests: Exotic Fruit Fly Surveillance.* Available at the QDPIF website, www.dpi.qld.gov.au/

New South Wales

The New South Wales Department of Primary Industries has a large file of information on control, quarantine and identification of fruit flies. It is available at www.agric.nsw.gov.au/reader/pe-qff

Victoria

The following information is available from the Department of Agriculture Victoria at the DPIV website, www.dpi.vic.gov.au

- Queensland fruit fly: *About Queensland Fruit Fly*.
- Mediterranean fruit fly: *About Mediterranean Fruit Fly.*
- *Travelling within Victoria: Fruit Fly.*

South Australia

The following information is available from the Department of Primary Industries and Resources, South Australia, at the PIRSA website, www.pir.sa.gov.au/index.shtml

- *The Sterile Fruit Fly Release Program*
- *The Fruit Fly Exclusion Zone*
- *Identification of Fruit Fly*
- *Travel into South Australia: Quarantine Requirements*

A fruit fly fact sheet (FS 21/77/02) is available at www.pir.sa.gov.au/pages/agriculture/horticulture/fruitfly/fs2177_web.pdf

Leaf curl

Taphrina deformans

IPDM quick facts

Sample unit: *Leaves*

When to monitor: *Early leaf onwards*

How often: *Fortnightly*

Action level: *If the block has previously been infected, and*

- *the temperature around budswell is 20 to 26 °C*
- *it is warm and humid around the time of budswell. If the disease is present you must take appropriate action early next season.*

Causes and consequences

Leaf curl is caused by the fungal pathogen *Taphrina deformans*. If untreated, it is one of the most serious and common disease of peaches and nectarines.

Distortion and loss of foliage result in reduced fruit production. The disease can also disfigure fruit and reduce pack-out.

Symptoms

Symptoms of leaf curl appear early in the season, approximately 1 month after flowering starts. The disease causes symptoms on the leaves, shoots, blossom and fruit. Leaf curl is commonly seen in the tops of trees where spray coverage (with protectant fungicides) has not reached.

Leaf curl on nectarine

Leaves

On young leaves, infected portions may be pink to red.

These areas become thickened and do not expand at the same rate as healthy leaf tissue. This leads to the characteristic curled appearance of leaves in this disease.

The leaves tend to turn yellow and fall and are replaced by new growth. The energy required to develop this new growth reduces fruit set and size and weakens trees.

Shoots

Whole shoots can be infected, becoming swollen and stunted and pale green to yellow. They may exude gum. When this damage affects leaders, lateral branching may occur, leading to 'witches broom'. Young trees are particularly susceptible to shoot infection.

Fruit

Infected fruit has raised, irregularly shaped and roughened areas that may redden long before healthy fruits show any colour change. In peaches, infected fruits lack the normal amount of fuzz. Infected fruit is likely to drop before maturity.

A serious regional issue during the last 10 years in:

- Manjimup/Donnybrook
- Swan Hill
- NSW central west
- Tasmania
- Goulburn Valley

Pink–red infected leaves

Distorted, curled leaves

Prevention

Orchard management

Non-chemical methods are often ineffective in preventing leaf curl. Pruning out infected leaves, fruits and twigs does little to prevent the disease.

If leaf curl has been severe it is important to put extra effort into maintaining tree vigour. Thin more fruit than usual, ensure adequate irrigation and apply extra nitrogen fertiliser. This will ensure that the disease doesn't drastically shorten the life of trees.

Monitoring

In the case of leaf curl, monitoring in the current season determines the level of control necessary in the following season. If leaf curl is observed it will be too late to control the disease in the current season.

When to monitor

Monitor the weather from early budswell to mid-season. Because the leaf curl pathogen tends to infect during cool wet weather, the period of primary infection can be longer if these conditions occur beyond budswell (see chart below).

Primary infections are precisely timed to coincide with budswell, and it is important to monitor all varieties. Appropriate action (see below) also needs to be timed to coincide with budswell on earlier- and later-maturing varieties. Poorly timed monitoring and appropriate action will not be effective.

Carefully observe four lateral branches on the marked monitoring trees for leaf curl at fortnightly intervals from early leaf onwards. Because the symptoms are so obvious, you should observe the other trees in the orchard as you walk between the monitoring trees.

What to look for

Where leaf curl has occurred at any time during the last four seasons, weather favouring disease development should trigger appropriate action.

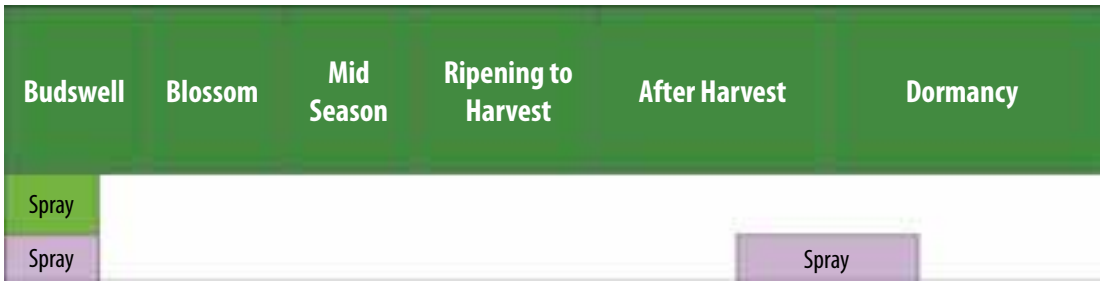
Also look for leaf curl symptoms, which indicate that early treatment next season is necessary.

Appropriate action

Action threshold

Take action if the block has been infected at any time during the last four seasons and

Budswell	Blossom	Mid Season	Ripening to Harvest	After Harvest	Dormancy
Primary infection	Development of leaf curl ceases when young tissue is not developing and the weather is dry and warm (27-30˚C)			Spores overwinter in cracks and crevices on the tree and in the bud-scales	
MONITOR					



- the temperature around budswell is 20 to 26 °C
- it's warm and humid around the time of budswell.

Symptoms of leaf curl indicate that appropriate action is required early next season (see chart above).

Treatments for leaf curl are not effective after infection has occurred or symptoms are seen. Monitoring should be aimed at determining the effectiveness of treatments and planning for the next season.

The appropriate action for this disease depends on the severity of the disease during the previous season.

Spray schedule 1: Infection light to moderate during previous season

Correct timing of this spray application is critical. The fungicides that are effective against this disease are listed in the spray schedules in this manual (page 137). Apply when the buds are swelling but before and within 1 week of bud opening. Because of the precision needed it is important to monitor bud development carefully. Do not rely on flowering times from previous years: flowering varies from year to year because of differences in the weather. Separate applications will need to be made for varieties that mature at different times. Blocks containing more than one variety may need to be treated more than once. Note also that the fungicides registered for use against this disease in peaches are different from those for use in nectarines.

Spray schedule 2: Infection moderate to heavy during previous season

Extra sprays need to be put on trees where leaf curl infection has been moderate to heavy.

Do not use this schedule on a regular basis. After you use this schedule, monitor to check its effectiveness and revert to schedule 1 if the disease level has dropped. Use this schedule for no more than two consecutive seasons. If problems persist, consult you adviser or district horticulturist.

- Apply a registered fungicide in autumn when 90% of leaves have fallen.
- Apply a registered fungicide at first sign of budswell and again 1 week later.

More information

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Hetherington S (2004) *Leaf curl of peach and nectarine.* New South Wales Department of Primary Industries Agfact H5.AB.12. Available through the NSW DPI website, www.agric.nsw.gov.au

Washington WS (1999) *Peach Leaf Curl.* AG0160. State of Victoria, Department of Primary Industries. Available through DPIV website, www.dpi.vic.gov.au/dpi/index.htm

Sivyer M, Wood P (1999) *Peach Leaf Curl.* Farmnote 24/96. Agriculture Western Australia. Available through the DAWA website, www.agric.wa.gov.au

Lightbrown apple moth

Epiphyas postvittana

IPDM quick facts

Sample unit: *Broad-leaved weeds*

When to monitor: *Budswell to shuckfall*

How often: *Fortnightly*

Action level: *10%*

Sample unit: *Fruit and leaves*

When to monitor: *Fruit ripening to harvest*

How often: *Fortnightly*

Action level: *3% to 5% of leaves infested; fruit infestation*

Take extra care when monitoring:

- *when cool conditions in spring extend into the summer*
- *during autumn when spraying for other pests has ended.*

The pest and its damage

Lightbrown apple moth (LBAM) is native to South Eastern Australia, including Tasmania, and has also been introduced to Western Australia, the British Isles, New Zealand, Hawaii and New Caledonia. It attacks nearly all types of fruit crops and many vegetables and ornamentals. LBAM is adapted to cooler conditions, causing major problems in the cooler regions of New South Wales, Victoria, South Australia and Tasmania.

Adults are about 10 mm long and variable in colour. They are usually yellowish brown, with darker brown markings on their wings.

Eggs are laid on the surface of almost any smooth-leaved plant, and tiny larvae emerge. These larvae undergo several growth stages as

Lightbrown apple moth

Lightbrown apple moths are variable in colour but are usually yellow-brown with darker brown markings

they become bigger, but their appearance remains essentially unchanged.

Larger larvae construct a feeding shelter by curling leaves with silken webbing and pupate to become adult moths.

Leaves

Young larvae construct a silken web on the undersides of leaves and feed on tissue beneath the upper surface. As the larvae grow, they migrate from these protective shelters and construct larger silken shelters between leaves, between leaves and fruit, or on single leaves. These later-stage larvae feed on all leaf tissue except the main veins. Feeding on leaves is not usually economically damaging, but the sticky webbing is uncomfortable for pickers.

Fruit

Feeding damage to fruit takes place beneath the protective canopy of webbed leaves. Feeding sites are shallow but can be extensive. This is particularly the case where larvae have found shelter in the middle of a fruit cluster. The larvae will cause damage to all fruit within the cluster.

A serious regional issue during the last 10 years in:

- Alstonville
- Granite Belt
- Goulburn Valley
- Sydney Basin
- Riverlands
- Tasmania

Prevention

Thinning

Larvae find enclosed, sheltered spots to spin their webs and feed. Thorough thinning reduces these sites and also allows for good spray penetration. Thin to singles if this is an option.

Weed control

Removal of broad-leaved weeds such as capeweed, mallow and dock from the orchard and surrounding areas reduces the number of overwintering sites for LBAM. Selective herbicides, mowing or grazing can be used to reduce these weeds. This job must be done before budswell. After budswell, larvae are large enough to crawl up and into the canopy of the trees.

Lightbrown apple moths pupate in webbing on leaves

Lightbrown apple moth larvae

Fruit damage

If LBAM has been a persistent and serious problem, consider planting an inter-row that does not support populations of larvae. Good options are oats or other grasses.

Clean up unpicked fruit

Clean up all of the fruit that is left hanging on trees in the orchard. Waste fruit must also be removed from any apple orchards nearby.

Monitoring

When to look

(See chart below)

1 Note that the LBAM life cycle is slightly delayed with respect to tree growth stages in Tasmania. Monitoring times should be adjusted.

Monitor broad-leaved weeds between budswell and early blossom.

Look at fruit and leaves on four lateral branches of each of the marked monitoring trees from mid-season to harvest, at fortnightly intervals.

What to look for

Monitor broad-leaved weeds for moth larvae. This can give some indication of how severe the LBAM problem may become in the orchard. Keep in mind, though, that the pest's development is closely linked to the weather. If the weather isn't suitable for development after blossoming, the problem may not be as serious as numbers on weeds may indicate. Nevertheless, high larval counts during this early-season monitoring should motivate you to be very thorough when you begin to monitor your trees as the fruit ripens.

Examine the fruit carefully. Only thorough examination will reveal the pest. Examine the stem end of the fruit in the centres of the trees. Pay particular attention to fruit clusters.

Examine the fruit in your other trees during your walk between the marked trees.

Appropriate action

Action threshold

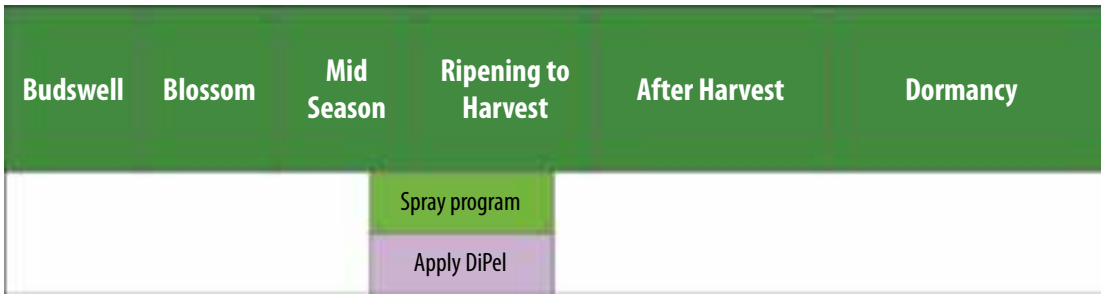
(See chart overleaf)

- 10% of broad-leaved weeds infested
- 3% to 5% of leaves infested
- fruit infestation

Protective spray program

Azinphos-methyl may be used for emergency control, but observe the 14-day withholding period. It will also control oriental fruit moth and help with *Carpophilus* beetle control.

Budswell	Blossom	Mid Season	Ripening to Harvest	After Harvest	Dormancy
Larvae pupate	Adults emerge	Eggs, larvae and pupae on ground cover plants	Larvae in summer fruit foliage. Larval damage to ripening fruit	Larvae in ground cover	
	MONITOR				



Thorough spray coverage is required. Up to three consecutive applications of indoxacarb will give the best results.

Apply DiPel®

DiPel® will not give adequate control in an emergency, but if LBAM is a regular problem, consider a program of DiPel®, especially if you are using oriental fruit moth mating disruption.

More information

Some of the information provided in these references comes from other countries (marked †). Always remember that the biology of pests and diseases and the tactics used to control them vary subtly from country to country and will change with time. Be particularly cautious with pesticide recommendations. If a pesticide is not recommended in this manual (page 137) you must check that it has current registration in your State and abide by the conditions of that registration, as specified on the pesticide's label. ALWAYS READ THE LABEL.

Mo J (2004). *Light Brown Apple Moth Development Calculator.* New South Wales Department of Primary Industries. Available through the NSW DPI website, www.agric.nsw.gov.au

Williams D (2000). *Lightbrown Apple Moth in Orchards*. Available through DPIV website, ww.dpi.vic.gov.u/dpi/idexh

Oriental fruit moth

Grapholita molesta

IPDM quick facts

Sample unit:	Pheromone trap	Food lure trap	Shoot tips	Fruit
When to monitor:	August–April	August–April	September–May	November–April
How often:	At least weekly	At least weekly, twice weekly August– October	At the end of each generation	
Action level:	Depends on variety, time of year and whether you are using mating disruption.		Depends on variety, time of year and choice of chemical.	
Helpful hints:	Traps need regular maintenance. Pheromone traps should not be used in blocks treated with mating disruption. Food lure traps catch both sexes. It is useful to count the sexes separately.		Damage is usually obvious, and this leads to biased sampling. It is important to take random samples of shoots and fruit. Also, select the trees at random.	

The pest and its damage

The oriental fruit moth (OFM) has been a serious pest in canning peach orchards of the Goulburn and Murray valleys around Cobram and Shepparton since the 1930s. It now infests cherries, fresh market peaches and nectarines, pears, apples, nashi, some apricots and plums, and quince. OFM is also considered a minor pest in parts of NSW (NSW southwest slopes, Alstonville, Sydney Basin) and South Australia (Renmark). In Alstonville its importance relates more to custard apples than to summer fruit.

Damage is caused by the larvae, which feed on shoots and fruit. Larvae bore into the tips of shoots, causing them to distort and dieback. These infestations are most apparent on the young, green actively growing shoots. During summer, OFM bore into fruit. Mature, softening fruit is most susceptible, but when the numbers of larvae are high immature fruit can also be attacked. The subsequent tunnels in the fruit make it unmarketable and are often an entry point for decay organisms such as bacteria and brown rot (page 27). When boring into both fruit and shoots, larvae excrete frass. This

Oriental fruit moth

Oriental fruit moth

Shoot tip damage caused by oriental fruit moth

Oriental fruit moth larvae in damaged fruit

excretion distinguishes wounds caused by OFM from those caused by mechanical damage such as hail.

A serious regional issue during the last 10 years in:

- Riverlands
- SE Queensland
- NSW southwest slopes
- NSW central west
- Alstonville
- Goulburn Valley

Prevention

Orchard management

OFM overwinters as hibernating larvae under bark and in cracks, wounds, and debris in the crotch of the tree. Smooth-barked, calm, well managed trees will generally support lower populations of OFM than will older, rougher, damaged, or highly vigorous trees.

Manage your trees to reduce vigour and limb breakage. OFM loves succulent shoots, and overwinters in wounds caused by broken limbs, or in cracks in wooden trellis posts.

Manage your trees for optimum spray penetration and regularly calibrate your spray machinery to ensure coverage of shoot tips and fruit. Regularly calibrate spray machinery so that it delivers the right amount of pesticide to the right part of the tree. Good coverage of growing tips is essential for OFM control.

Fruit bins

Never store other people's fruit bins on your property without thoroughly disinfecting them. OFM can hibernate in cracks in the bins and then infest your orchard. Bins that may be sources of OFM must be removed or disinfected before the first moth emergence in spring.

Left-over fruit and prunings

Before the start of moth emergence in August, destroy any large prunings or trees you have removed. Pay attention to fruit left on harvested trees. Leaving as little as three fruit per tree at 275 trees/ha can easily generate 500 moths/ha.

Fruit left on the tree after harvest (especially pome fruit) can become infested and cause a build-up of OFM without you being aware of it. Pome fruit blocks adjacent to summer fruit need particular attention after harvest.

It is important that you burn trees that have been bulldozed in previous seasons. Piles of old trees concentrate the moths, ensuring mating, and then the mated females will disperse into nearby trees. Eliminate this source of infestation.

The neighbours

OFM can fly relatively large distances (2 to 3 km) and can move from infested neighbouring orchards. Know your district and where likely sources of infestation are. Encourage neighbours to clean up neglected orchards on their boundaries and ask them to tighten up their OFM control. Although OFM is principally a

pest of peaches and nectarines, it can also infect other types of summerfruit, apples, pears and quinces. Neighbouring blocks of pome fruit can also be sources of infestation. As a result, control along your boundaries neighbouring these orchards may need to be strengthened (see 'Appropriate action' below).

Monitoring

Before monitoring, decide whether you believe you can use mating disruption to control OFM. The choice of whether or not to use mating disruption will determine the type of monitoring you use (see chart below).

Mating disruption

Mating disruption is suitable for orchards:

- that are isolated from other summerfruit or pome fruit orchards that may act as reservoirs of OFM
- that are part of an area-wide management scheme (e.g. Cobram)
- where both external (moth migration) and internal sources (e.g. infested bins) of OFM can be successfully managed
- where OFM numbers are low but cause sufficient damage to warrant investment in mating disruption.

When to look

Moth flights start in August and can be detected using pheromone traps or lure pots. Traps should be inspected twice a week early in the season and when each generation of moths is expected to start flying. Infestation by larvae can occur at any time from late September and continue throughout the season.

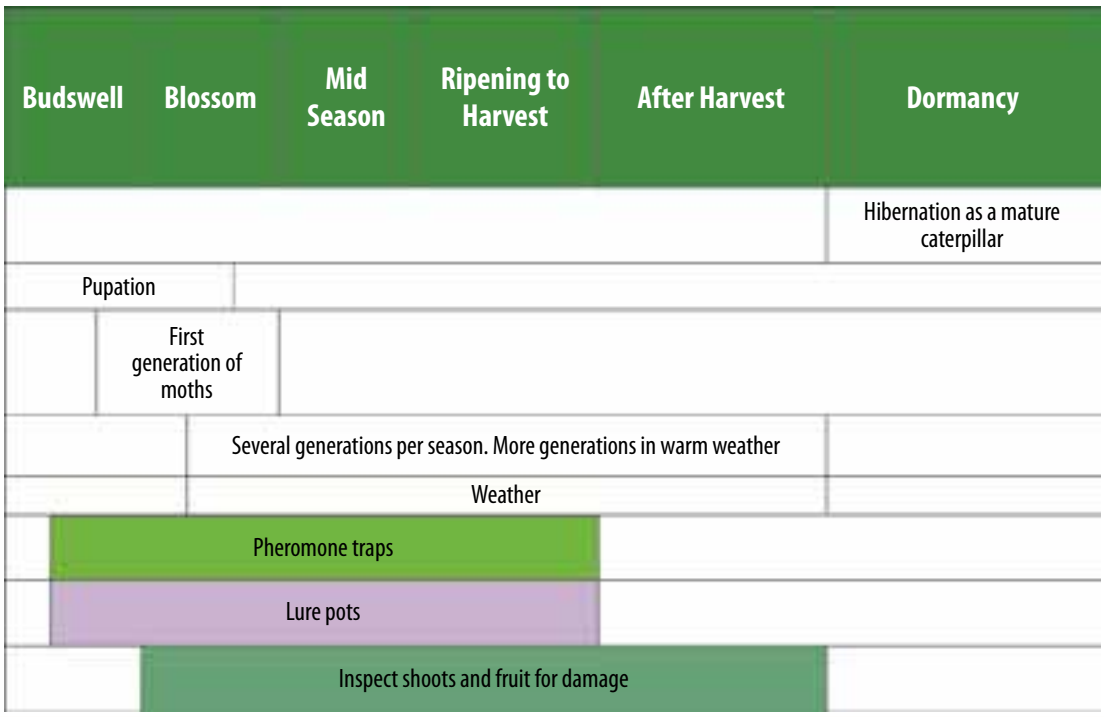
Shoots should be inspected from early spring. Fruit is more susceptible to infestation approaching harvest but should be inspected earlier, as immature fruit can be infested when numbers of larvae are high. Later-maturing varieties are generally most seriously affected by fruit infestation.

Pheromone traps

Pheromone traps **cannot** be used in orchards that use mating disruption. Pheromone traps rely on scents (pheromones) to attract male moths to a point source where they're trapped on a sticky surface. Pheromone traps are not very useful in blocks being treated with mating disruption because the mating disruption pheromone makes it difficult for the moths to find the traps.

Set traps at head height towards the outside of the tree canopy and at a density of 1 trap/1–3 ha. It is preferable to have a minimum of two traps in any block, and the traps should be at least 50 to 60 m apart. Monitor traps twice a week during the early part of the season.

Being able to detect OFM in the orchard very early in spring gives us some useful information. The rate at which the OFM life cycle, and consequently orchard infestation, occurs depends on the weather—primarily the temperature. Traps are placed in the orchard at early budswell,



aiming to trap the first flight of OFMs for the season. The date on which moths are first caught is called the biofix.

Because the growth rate of an insect increases as temperature increases until the optimum temperature for that insect is exceeded, insect growth is measured in physiological time units (degree-days) instead of chronological time units (hours, days). There are a number of ways to calculate degree-days, and computer models that do this are used by consultants to forecast various stages of insect development.

Maximum and minimum daily temperatures should be read every day after biofix using a max-min thermometer. For OFM, a rough approximation of degree-days for each day can be obtained from the formula:

$$\text{Degree-days} = \frac{(\text{Max} + \text{Min})}{2} - 7.5$$

where Max and Min are the daily maximum and minimum temperatures in degrees Celsius. OFM hibernates over winter as a mature caterpillar and transforms into a moth in late winter or early spring. The moths have to mate and lay eggs, and the eggs need to hatch before an infestation starts. It takes about 110 degree-days from moth catch to egg hatch. This could take a few weeks in cool spring weather.

The time between each generation is about 555 degree-days. In warm weather, degree-days are accumulated more rapidly than in cool weather.

Using this information allows orchardists to time appropriate action and minimise unnecessary control.

Lure pots

Lure pots **can** be used in orchards that use mating disruption. Because they rely on the scent of food, they trap both male and female moths. The information from lure pots can be used to determine the biofix and calculate the physiological state of OFM in the same way as the information from pheromone traps (see section above).

Additionally they can be used throughout the season in mating disruption orchards to monitor the numbers of moths and the performance of mating disruption.

An effective food lure can be made by dissolving 100 g of brown sugar in a litre of warm water. Add 12 drops of terpinyl acetate solution, made from mixing 48.5 mL of terpinyl acetate with 1.5 mL of non-ionic wetting agent and 50 mL of warm water. Then pour the solution into the lure pot. Lure pots can be constructed from commercially available fly traps. Change the sugar and terpinyl acetate solutions each week during the monitoring periods. Lure pots are messy to use, and the liquid often removes scales from the moths' wings, making them difficult to identify. Lure pots also require frequent maintenance to function properly. Pest management consultants and scouts are available to monitor OFM lure pots, and the relatively low cost of such a service is well worth it.

Lure pots have relatively low drawing power, so you need more lure pots than you would pheromone traps. Costs can be reduced by concentrating on known OFM hotspots within the orchard.

Inspect shoots and fruit for damage

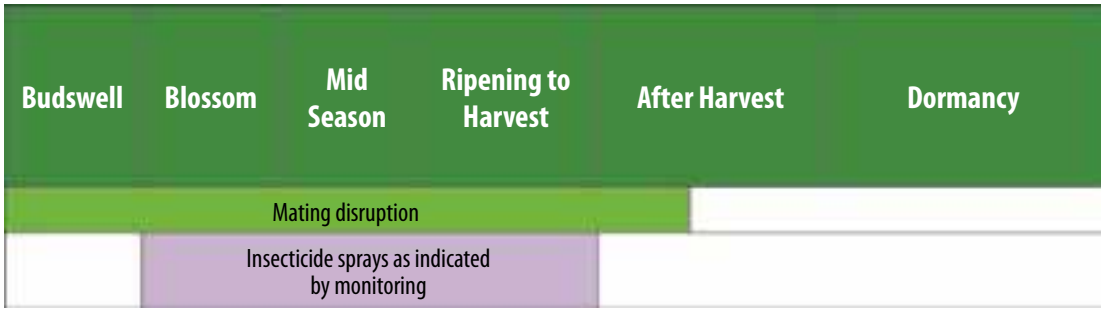
Wilting lateral tips are the first symptoms of infestation on summer fruit.

When such tips are split longitudinally, a tunnel following the centre of the lateral can be seen. Sometimes a cream to pale pink caterpillar up to 12 mm long will be found at the end of the tunnel. The caterpillar will often leave the tunnel and bore into another shoot tip, or tunnel into a fruit. Infested tips die.

Damage usually appears in the leaf axils, starting as sawdust and progressing as a downward tunnel.

Fruit damage occurs when the caterpillars enter the fruit and burrow towards the centre, filling

Young tree with an oriental fruit moth infestation



the tunnel with brown particles of excrement and often causing summer fruit to exude gum.

Shoot tip damage Assessment of shoot tip damage can indicate potential problems in the next generation. A single OFM larva can infest up to seven shoot tips. Shoot tip assessments can be done by randomly selecting 10 trees in a block. Inspect 100 shoots at random from each tree. Damage is obvious, and the assessment does not take very long. Time your inspections to coincide with the end of each OFM generation so that you can make decisions about how to manage the coming generation.

Fruit damage. An inspection process similar to that used for shoot damage assessment is used. Use 10 trees × 100 fruit. Fruit does not need to be picked from the tree. OFM generally does not infect fruit until the third generation, so there is no value in checking fruit until the end of November, unless your orchard has a history of damage to early varieties.

Appropriate action

(See chart above).

Mating disruption

Mating disruption is based on a massive release of the chemical dodecanyl acetate. This chemical is usually released by the female moths to act as an attractant to male moths. Commercial dispensers of this chemical release so much of the chemical that male moths become disorientated and can't find a female and mate; subsequently, no fertile eggs are laid. OFM larvae are therefore not available to infest shoots and fruit. Mating disruption is the preferred method of OFM control in IPDM orchards. It provides the following advantages:

- no effect on non-target organisms means that beneficials are unharmed and secondary problems (e.g. mite outbreaks) don't occur
- no residue concerns
- reduced use of sprays mean fewer resistance concerns
- no mammalian toxicity means greater safety than with pesticide alternatives such as azinphos-methyl.

Twist each mating disruption dispenser one and a half times around a branch that is within 1 m from the top of the tree. You can avoid girdling the branches by placing the dispensers on branches that will be pruned off within 2 years. Apply dispensers at a rate of 500/ha to give an even distribution through the orchard. Apply them at very early budswell.

In many cases mating disruption will provide sufficient protection to keep your crop OFM-free for the entire season. OFM dispensers will last more than 180 days in the orchard under warm growing conditions. However, there are a number of reasons why OFM populations may increase to a point where mating disruption needs to be supplemented by insecticidal sprays:

- The male OFM doesn't rely only on scent to find a female mate. In some cases, particularly where large numbers of moths are present in the orchard, males and females come close enough by chance to see each other and mate.
- If neighbouring orchards aren't protected against OFM, mated females may migrate into orchards protected by mating disruption and lay eggs.

It's therefore important to maintain monitoring throughout the season with lure pots, even when you believe that your orchard is protected. Be especially vigilant when predictive models (see 'Pheromone traps' above) indicate periods of peak egg-laying. The third and fourth generations are often when populations and damage increase rapidly. We don't know why, but you need to be prepared.

Insecticidal sprays, as indicated by monitoring

In an orchard **not** using mating disruption, insecticidal sprays will need to be used. By monitoring with pheromone traps and using predictive models, you can apply sprays when they have the most effect against OFM. The

pesticides that can be used for this purpose are listed in the spray schedules included in this manual (page 137).

More information

Some of the information provided in these references comes from other countries (marked †). Always remember that the biology of pests and diseases and the tactics used to control them vary subtly from country to country and will change with time. Be particularly cautious with pesticide recommendations. If a pesticide is not recommended in this manual (page 137) you must check that it has current registration in your State and abide by the conditions of that registration, as specified on the pesticide's label. ALWAYS READ THE LABEL.

Botha J, Hardie D, Poole M, Reeves A (2004) *Oriental fruit moth (Grapholita molesta). Exotic Threat to Western Australia*. Department of Agriculture Western Australia. Factsheet No. 4/2004. Available through DAWA website, www.agric.wa.gov.au

Il'Ichev A (2004) *Area-wide Mating Disruption for Oriental Fruit Moth and Codling Moth Control in Fruit.* Department of Primary Industries Victoria. Available through DPIV website, www.dpi.vic.gov.au/dpi/index.htm

Il'Ichev A (2004). *Integrated Pest Management Strategy Using Pheromones for Control of Oriental Fruit Moth and Carpophilus Beetles in Orchards.* Department of Primary Industries Victoria. Available through DPIV website, www.dpi.vic.gov.au/dpi/index.htm

Mansfield C, Il'Ichev A (2000) *Oriental Fruit Moth Control Method*. IHD Media Release, 27 November. Available through DPIV website, www.dpi.vic.gov.au/dpi/index.htm

Ridland P(1997) *Dispersal of Oriental Fruit Moth.* Department of Primary Industries Victoria. Available through DPIV website, www.dpi.vic.gov.au/dpi/index.htm

Williams D (2000) *Oriental Fruit Moth.* AG0156. Department of Primary Industries Victoria. Available through DPIV website, www.dpi.vic.gov.au/dpi/index.htm

Peach white scale

Pseudaulacaspis pentagona

IPDM quick facts

Sample unit: *Trunks and branches*

When to monitor: *Harvest to dormancy*

How often: *Weekly*

Action level: *If present*

Take extra care when monitoring:

- ***under nets***
- ***during hot, humid weather.***

The pest and its damage

As with other scale insects, white peach scale (WPS) exists in several forms depending on the sex and age. The most commonly seen scales are immature males that form encrustations on the trunk and scaffold branches. Females disperse throughout the tree and are less conspicuous. The female is a creamy white to orange sac-like insect that is protected under a circular, convex, white, waxy scale 1 to 2.25 mm in diameter. The scale on immature males is more elongated. Adult males emerge as winged insects from under these scales after approximately five moults and live for only around 24 hours, during which time they must find a female and mate. Females lay eggs from which six-legged nymphs, called crawlers, emerge. The speed with which the insect completes its life cycle is related to temperature. In warmer regions in the USA (Florida) WPS can complete 3 or 4 generations during the peach-cropping season. The number of generations under Australian conditions is unknown.

Peach white scale can infest bark fruit and leaves. As with other scales it feeds by sucking the juice from plant organs. Severe infestations can cause stunting, premature leaf drop and death of entire branches. If the infestation is left untreated for 2 or 3 years entire trees can be killed.

Peach white scale

A serious regional issue during the last 10 years in:

- SE Queensland
- Alstonville

White peach scale is most common on peaches and nectarines under netting and is a particular problem in warmer coastal regions. Although in many respects it is similar to San José Scale (page 74) it is a more serious pest in some regions.

Prevention

Pruning

Prune out infested branches and burn. This will also improve spray penetration.

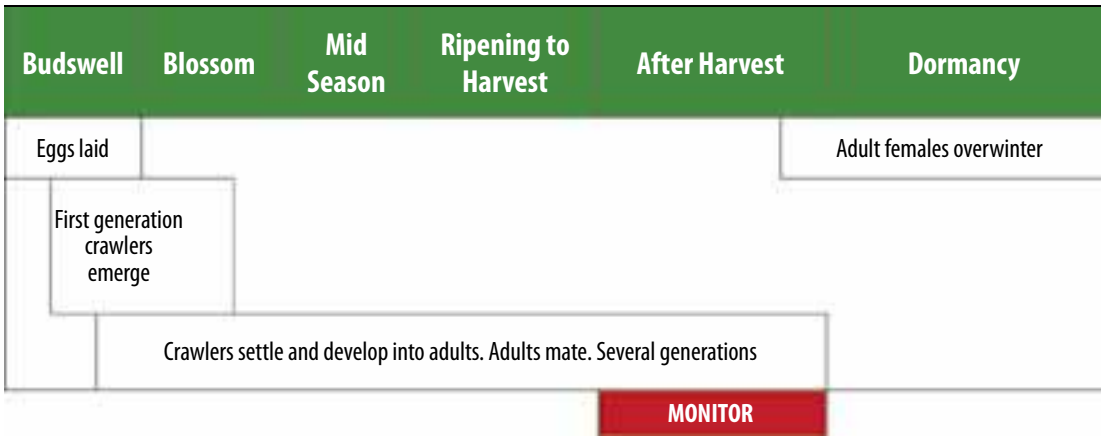
Orchard management

WPS is most common in warmer coastal regions under netting. This would suggest that WPS is more severe given high humidity. Anything that you can do in your orchard to reduce humidity is likely to reduce the impact of WPS.

- Don't over-water, particularly where you are using water-retaining mulches.
- When designing new blocks, orientate them so that the rows are parallel with the prevailing breezes.
- Remove unnecessary windbreaks and prune the undergrowth in windbreaks when necessary.

Neglected trees and other hosts

WPS can build up heavily on neglected fruit trees (particularly seedlings) around orchard areas. It can also infect a wide range of other trees. In the USA it infects several hundred species. Although it is unclear how many plant



species can be infested in Australia there are likely to be large numbers. Therefore, unnecessary vegetation that may serve as an alternative food source for WPS and a reservoir for infestation of orchards should be removed. Be particularly careful with privet, mulberries and persimmons.

Monitoring

When to look

This life cycle information is approximate and is based on information from southern USA. Very little WPS research has been conducted in Australia. As with San José scale, monitoring should aim to determine the severity of the infestation late in the season, after harvest. Infestations will be easier to see at this stage and the infestation severity will give a more accurate indication of the number of scales that will be carried over into next season (see chart at top of page).

What to look for

The most obvious symptoms of WPS infestation are encrustations of male scale. These encrustations give trees a fluffy to whitewashed appearance

Over the years, placing black electricians' tape with the sticky side out around the trunk of trees has been recommended. This is not practical under Australian conditions, as the tape rapidly collects so much dust that is no longer sticky.

Appropriate action

Action threshold

If scale is present (see chart below).

There are no insecticides registered for white peach scale. However, maintenance of a rigorous preventive spray schedule for San José scale will help to control white peach scale. In particular, thorough application of dormant oils for San José scale may preclude the need for any further control of white peach scale. A full control schedule for San José scale and details on application are provided on pages 76 and 137.

More information

Some of the information provided in these references comes from other countries (marked †). Always remember that the biology of pests and diseases and the tactics used to control them vary subtly from country to country and will change with time. Be particularly cautious with pesticide recommendations. If a pesticide is not recommended in this manual (page 137) you must check that it has current registration in your State and abide by the conditions of that registration, as specified on the pesticide's label. ALWAYS READ THE LABEL.

Robinson JV (1998) *Scale Insects on Peaches and Plums.* Texas Agricultural Extension Service, www.tamu.edu/extension/publications/sippaplum.html †