NSW DEPARTMENT OF
PRIMARY INDUSTRIES

Growing lemons in Australia- a production manual - Readers' Note

This document is part of a larger publication. The remaining parts and full version of the publication can be found at:

http://www.dpi.nsw.gov.au/agriculture/horticulture/citrus/lemon-manual

Updated versions of this document can also be found at the above web address.

11. Pests

INTRODUCTION

Lemons are susceptible to a wide range of pests. The incidence and importance of these pests varies between growing regions and seasonal conditions. In warmer climates there is usually a greater number of pests and pest generations in a single year than in cooler areas.

This section outlines the main pests affecting Australian lemons and provides detailed information on some of the more common and economically damaging pests in commercial lemon orchards.

Orchards should be regularly monitored throughout the year so that pest problems are identified and controlled as early as possible to avoid crop and tree damage and make control easier.

Control of pests should involve a combination of methods including cultural and biological controls and if necessary the targeted use of selective pesticides.

For more information on pest control products refer to the Pest and Disease Control section of this manual

SCALE INSECTS

Scale insects are one of the main pests of citrus. They are sap-sucking insects. There are two types - hard (armoured) and soft scales.

Hard Scales

Hard scales have a hard protective cover that, depending on the stage of the life cycle, is either attached to or separated from the body of the insect. Except for the first stage or crawler, the immature stages and the adult females do not move. Light infestations of hard scales are a problem as blemishes on fruit. At high levels of infestation they cause severe blemishing and can severely damage and even kill trees.

Examples of hard scales include:

- *Red scale*
- *White louse scale*
- *Yellow scale*
- *Purple (Mussel) scale*
- *Glovers scale*

☑ most prefer to settle on fruit, twigs and branches;

☑ are not associated with the presence of sooty mould;

☑ monitor most species from October to May;

☒ reduce tree vigour and productivity;

☒ blemish fruit causing down grading of fruit quality.

White louse scale on lemon tree causing bark splitting

Photo by Greg Moulds

Red scale on lemon fruit

Summary Of Common Hard Scale Types In Citrus

Hard Scales			
Pest	**Region**	**Appearance and Damage**	**Occurance, Conditions and Monitoring**
Red	All areas	Red brown and circular (2mm) on fruit, leaves, twigs and branches.	Prefers exposed sites on outsides of fruit and trees. Prefers temperatures of 30-38ºC. Good autumn rainfall followed by a dry summer increases populations. 2-6 generations/year. Monitor from fruit set to harvest (October-May).
Yellow	NSW, Vic, SA	Yellowish and circular (2.5mm) on fruit and leaves.	Prefers temperate shady conditions on inside parts of tree and undersides of leaves. 2-4 generations/year. Monitor from fruit set to harvest (October-May).
Circular black	Qld, Coastal NSW and NT	Black to dark red and circular (2mm) on leaves and fruit.	2-6 generations/year. Monitor from fruit set to harvest (October-May).
White louse	Qld, Coastal NSW	Thin long and white (1mm) on branches, trunk, twigs, fruit and leaves.	3-6 generations/year. Monitor all year. Prefers dry conditions.
Mussel (purple)	NT, Qld, Coastal NSW	Light brown and mussel shaped (3-4mm) on fruit, leaves, twigs and branches.	2-6 generations/year. Monitor from fruit set to harvest (October-May). Prefer warm moist conditions.
Glovers	Qld, Coastal NSW	Light brown long and slender (5-6mm) on fruit, leaves and twigs.	2-6 generations/year. Monitor from fruit set to harvest (October-May).
Chaff	Coastal Qld and NSW	Grey brown and oval (1.5mm) on leaves, fruit, twigs and branches.	5-6 generations/year. Monitor from fruit set to harvest (October-May).

Soft Scales

Soft scales have no separate cover.Usually the upper surface is hard and leathery or has a protective waxy or mealy secretion. Movement is usually possible, though limited after the first stage. The soft scales are not as damaging to trees as armoured scales but they produce a sugary honeydew fluid on which sooty mould grows and blemishes fruit and leaves. The honeydew also attracts ants, which protect the scale insect and disrupt the activity of natural enemies of both scales and other citrus pests.

Examples of soft scales include:

- *White wax scale*
- *Black (Brown olive) scale*
- *Hard (Chinese) wax scale*
- *Soft brown scale*
- *Pink wax scale*

☑ most prefer to settle on leaves and twigs;

☑ timing of sprays critical. Wait for egg hatch to be completed;

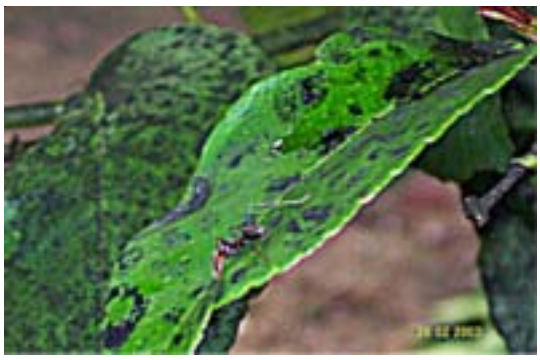
☑ produce honey dew;

☑ ants present (they feed on honey dew and defend scales against natural predators);

☑ ants must be controlled;

☑ sooty mould present (grows on honey dew);

☒ damage is mostly due to downgrading of fruit quality.



Sooty mould growth on foliage

Ants must be controlled

Summary of Common Soft Scale Types in Citrus

Soft Scales			
Pest	**Region**	**Appearance and damage**	**Occurance, conditions and monitoring**
Citricola	WA, SA, Vic, Inland NSW	Grey brown mottled and flattened (3-4mm) on young leaves and twigs.	1-2 generations/year. Monitor October-November and March-April.
Green coffee	Qld	Pale yellow green, oval and flattened (3-4mm) on young leaves, twigs and fruit.	3-4 generations. Monitor October-December.
Soft brown	All areas	Tan-brown (3-4mm) on leaves, twigs and fruit.	2-5 generations/ year. Monitor in October-December and February-March. Prefer warm dry conditions.
Long soft	Qld and Coastal NSW	Grey-brown and flattened (4-6mm) on twigs and leaves.	4-6 generations/year Monitor in October.
Black	All areas	Black dome shaped with "H" on back (3-5mm) on twigs and leaves.	2-4 generations/ year. Monitor in November-December and February-March. Prefer moderate conditions with high humidity.
Hemispherical	Qld	Glossy light to dark brown, dome shaped (2-4mm) on leaves, twigs and fruit stalks.	4-6 generations/ year. Monitor in October-December.
Nigra	Qld	Shiny dark and oval (33-4mm) on leaves, twigs and fruit stalks	4-6 generations/ year. Monitor October-December.
Cottony cushion	Qld	Long yellow-brown with a cottony egg mass (3-5mm) on leaves and twigs.	2-3 generations/ year. Monitor October-December.
Pink wax	Qld, Coastal NSW and WA	Pink waxy and globular (3-4mm) on leaves and twigs.	1-2 generations/ year. Monitor October-December and February-March. Prefer humid conditions.
Florida wax	Qld	Whitish, waxy and globular (2-4mm) on twigs and leaves.	2 generations/year. Monitor October-December.
White wax	All areas	Soft moist white waxy and globular (to 6mm) on twigs.	1-2 generations/ year. Monitor October-December and February-March. Prefer warm conditions with high humidity in summer.
Hard wax (Chinese)	Coastal NSW and WA	Hard dry dirty white waxy and globular (to 7mm). On leaves and twigs.	1 generation/year. Monitor in February. Prefer warm humid conditions.
Cottony Cushion	Qld, NSW, Vic, SA	Red brown with a white mealy secretion and fluted egg sac (to 5mm) on twigs, branches and trunks.	2 generations/year. Monitor October-December and February-March.

General control measures for scale insects

Scale insects have many natural enemies. Small wasps, both native and introduced, parasitise them. Ladybird larvae and adults, lacewing larvae, mites and several caterpillars are predators. Some fungi also attack scale insects.

Natural enemies help reduce scale infestations, but this natural balance can be upset by factors such as very hot weather, ant infestations and dust from nearby roads or cultivation. Spraying with broad spectrum insecticide sprays can also destroy natural enemies.

Soft scale infestations on newly planted or young trees are usually more significant than on older, full-bearing trees. Young trees should be more carefully and regularly examined.

Only use sprays where necessary. Biological control is effective in most orchards. If chemical control is needed, Horticultural Spray Oils (HSO's) are normally used. Thorough spraying is essential because HSO's work by smothering the scale insects. Therefore, HSOs need to be applied as high volume sprays - from 3,000-12,000 l/ha depending on tree height and density. Consider spraying heavily infested trees rather than whole blocks. Timing of sprays is critical for some scale types and is often carried out after egg hatch. For monitoring and control of scale insects, refer to the book *Citrus Pests and their Natural Enemies.*

- ☑ Monitor trees/fruit for scale insects regularly
- ☑ Chemical control may be targeted to infested trees and blocks
- ☑ Introduce predatory insects before scale populations explode
- ☑ Use HSO's in preference to broad spectrum pesticides
- ☑ HSO's need to be applied as high volume sprays to work.
- ☑ Control ant colonies (important for soft scale infestations)
- ☑ Reduce dust (important for hard scale infestations)

MITE PESTS

Mites damage the fruit, leaves, twigs and buds of trees. They cause fruit damage, fruit blemish and reduce tree growth and yield. They are very small and most are invisible to the naked eye. Mites pierce plant cells with their mouth parts and suck out the cell contents.

The main species affecting lemons include:

- *Broad mite*
- *Citrus bud mite*
- *Two-spotted mite*
- *Brown citrus mite*
- *Rust mite*

Photo by April Winchel
Mite damaged leaves

General Control Measures

Natural predatory mites and insects commonly feed on pest mites. The predatory mites (*Euseius* and *Amblyseius spp*.) play an important role in suppressing citrus red mite and citrus rust mites. The natural enemies of broad mite and citrus bud mite have not been studied in detail.

Many species of ladybirds occur in citrus orchards. The most common are *Halmus chalybeus,* (the steel blue ladybird,) *Serangium bicolor* and *Stethorus nigripes.* Adult *H. chalybeus* are round, about 4 mm in diameter and metallic blue in colour. This ladybird feeds on a wide range of insects and mites. Adult *S. bicolor* are slightly ovoid, about 2 mm long and black. Adult *S. nigripes* are oval, about 1.2 mm long and black. *S. nigripes* is the most common ladybird associated with heavy infestations of citrus red mite. Large numbers of adults and larvae of these three ladybirds have been observed feeding on heavy infestations of citrus red mite.

For more information, monitoring and control, refer to the book *Citrus Pests and their Natural Enemies.*

Most citrus mites are not readily visible to the naked eye. By the time damage has been observed, spraying would usually be too late to be worthwhile. Use a hand lens at frequent intervals to look for the mites at the times when infestation is expected to start. Higher magnification using a microscope is required to see some mite species. Pay special attention to trees recently sprayed with broad spectrum insecticides. Thorough spray coverage is essential. The incidence of mite damage is related to weather conditions and past levels of infestation.

- ☑ damage fruit and leaves;
- ☑ infestations reduced or killed by very hot dry conditions;
- ☑ most are very small and difficult to see without a hand lens;
- ☑ prefer warm humid conditions;
- ☑ damage to fruit is mostly surface scarring and russetting.

- ☑ Mites prefer warm dry weather
- ☑ Early detection is critical for control
- ☑ Use a hand lens to monitor leaves and fruit
- ☑ Monitor frequently at critical times
- ☑ Keep in mind previous season damage
- ☑ Very hot dry conditions reduce or kill mites

Broad Mite

Broad mite can seriously blemish lemons, especially the intermediate crops which are produced from summer and autumn blossoms in warmer coastal areas. When affected by broad mite, fruit are blemished severely during the first few weeks of growth, when 1 to 4 cm long. The injury shows up as an extensive silver coloured blemish often extending over the whole fruit surface.

Broad mite damage

Main crop lemons are usually not damaged much. They are produced from a spring blossoming and are beyond the susceptible size range when weather conditions favour development of broad mite.

Broad mite can also damage young foliage, causing problems especially with nursery trees. Young, tender foliage becomes infested and the mites can be found on the undersides of the leaves. Affected leaves become narrowed and distorted, with a pronounced downward curling of the margins, and are often bronzed on the lower surface.

- ☑ Prevalent from mid-spring to autumn
- ☑ Monitor newly set fruit frequently from November-May
- ☑ Fruit most susceptible when 1-4 cm long
- ☑ Likes warm humid conditions in summer and autumn
- ☑ Prevalent at flowering and fruit set.

Bud Mite

Citrus bud mites feeding in the foliage and flower buds cause distortion of shoots, deformed blossoms and sometimes deformed fruit. Foliage produced from infested buds is seriously distorted. Rosetting or bunching of leaves at the apex of the shoot is common. Bud mite damage to the blossom buds causes deformed flowers and these sometimes set and produce distorted and sometimes grotesquely shaped fruit.

Lemon bud mite damage causes deformed fruit

- ☑ Mites are difficult to see
- ☑ Intermediate crops more susceptible
- ☑ Lisbon lemons very susceptible
- ☑ Prefer warm humid conditions

Summary of Main Mite Types in Citrus

Mites			
Pest	**Region**	**Appearance and Damage**	**Occurance, Conditions and Monitoring**
Brown citrus mite	All areas	Infests young green fruit, also present on leaves and twigs. Damage is smooth, shiny brown to grey black stippling (indistinct margins) on exposed fruit surfaces. The damage can be scratched off.	Prefers warm humid conditions. Prefers exposed sites on outside surface of fruit and fruit on the outside of trees. 20-30 generations a year. Monitor from November-May with a 10x hand lens.
Citrus rust mite	All areas	Infests leaves, twigs and developing fruit. Damage is smooth shiny dark brown stippling on protected fruit surfaces. The damage can't be scratched off.	Prefers humid conditions. Prefers protected sites on insides of fruit and fruit inside trees. 20-30 generations/year. Monitor from November-May with a 10x hand lens.
Citrus bud mite	Qld, NSW, WA	Feeds on leaf buds and blossoms causing distortion of developing fruits. Lisbon lemons especially susceptible. Intermediate crops more susceptible.	Occurs during flowering and fruit set from September to February. 20 generations a year. The mite is difficult to see even with a 10x hand lens.
Broad mite	Qld, Coastal NSW and WA	Feeds on young foliage and newly set fruit. Damage to the fruit surface, resulting in a silver-grey, smooth blemish. The damage can be scratched off. Lemon fruit are particularly susceptible when small.	Prefers warm humid conditions in spring and summer. 20-30 generations/year. Monitor between September-December with a 10x hand lens.
Two spotted mite	All areas	Mites feed on leaves and fruits causing a yellow to pale green speckling on leaves and dull coloured fruit. Meyer lemons are especially susceptible.	Prefer warm humid conditions in spring and summer. 10-20 generations a year. Monitor from October to May using a 10x hand lens.
Other Mites	**Region**	**General Information**	
Oriental spider mite	Qld	Pale stippling of leaves and fruit. Monitor between October-May.	
Citrus red mite	Gosford and Sydney	Pale stippling of leaves and fruit. Monitor between August-October. Prefers dry conditions with mild temperatures in spring and autumn. Quarantine Pest. Trees must be treated if being sent outside the NSW counties of Northumberland and Cumberland.	
Citrus flat mite	Qld, NSW, Vic, SA	Grey spotting and scarring of fruit. Monitor between November-May.	

BUGS AND BEETLES

Summary of Main Bugs and Beetles Affecting Citrus

Pest	Region	Appearance and damage	Occurence, conditions and monitoring
Bugs			
Spined citrus	Qld, NSW, Vic and SA	Green shield bug with spines on shoulder. Pierces rind causing internal browning, gumming and dryness and causing fruit drop.	Adults can fly and exude a caustic liquid when touched. There are 5 nymph stages which can't fly. 3-4 generations/year. Monitor all year.
Bronze orange	Coastal Qld and NSW	Black shield bug. Sucks young shoots and fruit causing tip wilting and fruit drop.	Adults can fly and exude and caustic liquid when touched. There are 5 nymph stages which can't fly. 1 generation/year. Monitor spring-early summer. Prefer warm humid conditions with summer rainfall.
Beetles/Weevils			
Fullers rose weevil	Qld, NSW, Vic and SA	Feeds on foliage causing pitting. Lays eggs under calyx causing a problem for export fruit.	1 generation/year. Monitor August-October and February-June.
Citrus branch borer	SE Qld and Coastal NSW	The larvae feed inside branches and trunk causing branch death.	1 generation/year. Monitor spring to autumn. Weak trees, those recently pruned and those close to native bush are particularly susceptible.
Longicorns (several species)	Qld, Coastal NSW	Larvae tunnel into branches and trunks causing ringbarking and death. Evidence of frass.	1 generation/year. Monitor spring to autumn.

Borer damage showing frass

Spined Citrus Bug

Spined citrus bug is a native insect pest that damages lemons causing fruit loss. The pest can cause significant damage in southern citrus growing regions. In commercial orchards in coastal areas of NSW they rarely cause significant crop loss.

The pest

The adult is a lime-green bug approximately 20 mm long, with a sharp spine on each shoulder of the thorax. Adults fly strongly and can eject a caustic liquid when disturbed.

The young bugs go through five nymphal stages before becoming adults. The nymphs are variously marked with black, green or orange in the early stages, becoming green at later stages.

The bugs are active between September and May. Overwintering females start laying eggs in September and all stages of the bug can be present on trees during this time.

Damage

The bugs damage fruit by feeding with their piercing and sucking mouthparts. Only a few bugs are needed to cause heavy fruit loss.

Fruit is mostly attacked when half-grown, causing them to colour prematurely and fall. When more advanced fruit are attacked they do not tend to fall but are damaged internally (internal drying, browning and sometimes gumming).

Control

Chemical control, if warranted, should be aimed at the immature stages when the bugs cannot fly.

Photo by Greg Moulds

Nymphs of spined citrus bugs

Photo by Greg Moulds

Adult spined citrus bugs

- ☑ Monitor between September and May
- ☑ Chemical control should be aimed at the wingless immature nymphs
- ☑ Once the bugs have developed wings control is difficult
- ☑ Young fruit colour prematurely and fall
- ☑ Damage fruit, causing internal browning and drying
- ☑ Prefer warm conditions with moderate humidity

MOTHS AND CATERPILLARS

Summary of Main Moths and Caterpillars Affecting Citrus

Pest	Region	Appearance and damage	Occurance, conditions and monitoring
Orange fruit borer	Qld, NSW, NT	Larvae bore into fruit causing pitting. Fruit colour prematurely and drop.	Prefers protected sites under calyx and where fruit touch. 5-6 generations/ year. Monitor summer-autumn.
Citrus rindborer	Qld, NT	Larvae feed on young foliage and fruit surfaces and and bore into fruit. Fruit fall.	7 generations/year. Monitor October-April. Prefers protected sites.
Lemon bud moth	Qld and Coastal NSW	Larvae feed on buds and flowers.	6-7 generations/ year. Monitor summer-autumn.
Citrus leaf roller	South Qld and Northern NSW	Larvae feed on young leaves	10 generations/year. Monitor November-March.
Citrus leaf miner	All areas	Larvae tunnel into new leaves in summer and autumn causing distortion and leaving silvery trails.	Monitor late December-March. Control usually only warranted in young trees.
Light brown apple moth	NSW, Victoria, SA	Caterpillars feed around stem end of fruit causing "halo" scars and fruit drop.	3-4 generation/year. Monitor all year. Prefer mild moist conditions.

Citrus Leafminer (CLM)

- ☑ Infest the summer autumn flush
- ☑ Sprays normally only required for moderate-severe infestations in young trees
- ☑ Use HMO's and thoroughly apply to flush growth
- ☑ Early application (mid-late January) prevents rapid growth of CLM populations

Symptoms

Larvae mining damages immature foliage. Twisted and curled leaves are generally the first symptoms you will see. Severe infestations - an average of two or more mines per leaf - can retard the growth and yield of nursery and newly planted trees, but their effect on mature trees is less serious. Trees are usually only infested in late summer and autumn. CLM rarely occur in spring because the production of new growth is prolific and synchronised, and quickly becomes immune to attack.

The pest

Citrus leafminer (CLM) is a small moth pest of citrus. Under favourable summer and autumn conditions a generation is completed in 14 to 17 days. In late autumn, winter and spring it can take two or three times longer.

The adults are small delicate moths 2 mm long with narrow paired forewings and hindwings fringed with long hairs. Adult female moths start laying eggs about 24 hours after mating. A female can lay more than 50 eggs during her life and as many as 20 per night. The peak egg laying period occurs between mid-February and mid-March. Most adults live for less than a week but they can live for up to 20 days.

The flat, slightly oval eggs are about 0.3 mm long. Eggs are laid singly, on the underside of leaves near the midrib. Hatching can occur within one day in summer and the young larva immediately burrows under the surface of the leaf.

There are four larval stages. The first three feed only on sap and epidermal cells ruptured by their mouthparts. Each pale green larva forms a characteristic silvery mine on leaves. The fourth stage does not feed. It lasts for about one day in summer and forms a pupal chamber, usually located on the leaf margin, the edge of which is rolled over.

The yellowish brown pupae are about 2.5 mm long. After about six days the adult moth emerges.

Control

Because infestations are restricted to flush growth, particularly in late summer and autumn, their severity can be reduced by:

- fertilising in winter to promote flush growth in spring when the pest is either absent or relatively scarce;
- limiting flush growth in late summer and autumn by not over fertilising or over irrigating during summer and autumn.

Natural enemies include small parasitic wasps and predators such as lacewings. The predators are generally associated with heavy infestations.

Minimising infestations using chemicals is difficult because larvae are protected by their mines and pupae are protected by their pupal chambers. Sprays are usually only required for moderate and severe infestations on young or vigorous trees in summer and autumn.

Horticultural mineral oils (HMO's) and Agricultural mineral oils (AMO's) give good control of CLM. Early application of oils to the new summer flush growth (in mid to late January) prevents rapid growth of CLM populations and reduces the risk of heavy infestations later in the season. Female moths lay fewer eggs

on oil sprayed leaves and the oil deposits also influence moth movement between and within trees.

Severe leaf miner damage can cause leaf curling

Spraying of mature trees specifically for leafminer should only be considered if trees are moderately to severely infested, and when they may be an important source of infestation on adjacent immature trees. When sprays are required, they must be applied thoroughly to the upper and lower surfaces of susceptible leaves. Trees should be sprayed to the point where the spray just starts to drip off the leaves.

Two or more sprays may be needed, particularly in summer and autumn when flushes are produced over a long interval. Young and vigorous trees will need to be sprayed more frequently than mature trees or trees with low vigour. Also, lemon trees will generally require more sprays than orange, mandarin or grapefruit trees.

Spray moderate to severe infestations every 5-14 days during each growth flush. The interval between sprays will be shorter during summer and early autumn than in mid or late autumn.

For control of leafminer only, thoroughly and evenly spray flush growth using a low concentration oil spray (0.25-0.5%) at volumes equivalent to 3,500L/ha to 4m high trees.

Lemon Bud Moth

- ☑ Damages flowers and developing ovaries
- ☑ Infests summer and autumn blossoms
- ☑ Reduces fruit set

The larvae of this moth infest mostly the summer and autumn lemon blossoms in coastal areas. There has been very little research done on this pest in Australia.

The adult moth lays its eggs onto the small developing red flower buds during summer and autumn. The hatched larvae then bore into the developing flower buds and feed on the internal parts and ovary. The larvae then leave the bud and move onto a leaf where they form a lace-like cocoon on the curled leaf edge. Damaged flowers can be identified by a small hole in the developing flower bud. The flower buds are full of frass, webbing and are readily invaded by fungal pathogens (such as grey mould) in suitable conditions.

The complete lifecycle takes three weeks in summer but longer in autumn with the cooler temperatures. Lemon bud moth reduces fruitset by feeding on and damaging the developing ovary/fruit.

FRUIT FLIES

Summary of Main Fruit Fly Pests of Citrus

Pest	Region	Appearance and damage	Occurance, conditions and monitoring
Queensland fruit fly	NSW, QLD, NT	The fly stings fruit and larvae feed and develop inside. Fruit are normally stung when they start to colour, the sting site colours prematurely and fruit sometimes fall.	Up to 6 generations per year. Monitor spring through autumn. Meyer lemons are very susceptible. Eureka and Lisbon lemons are susceptible in inland areas where fruit have thinner skins.
Mediterranean fruit fly	WA	Fly stings fruit and larvae feed on pulp. Fungal pathogens invade stung fruit. Fruit are normally stung when they start to colour, the sting site colours prematurely and fruit sometimes fall.	4-5 generations a year. Monitor summer-autumn.
Papaya fruit fly	North Qld	As above	Monitor summer-autumn.

Queensland Fruit Fly

Queensland fruit fly (QFF) is a very serious pest of most fruit in Queensland and coastal and northern inland NSW and is most prevalent from October to May. In addition to the direct damage it can cause to the fruit, an infestation can have serious implications for movement of fruit beyond and within states, especially for export. Lemons are considered a marginal host for fruit fly and will be attacked when there are high numbers of flies, when fruit are already damaged (split) and when the fruit skins are thin.

Southern NSW is on the edge of the Queensland fruit flies natural range. A trade zone called the Fruit Fly Exclusion Zone (FFEZ) has been established to maximise the access to export markets by eliminating fruit flies from that zone and from nearby areas. The main horticultural production areas in this zone include Griffith, Narrandera, Leeton, Hillston and Broken Hill in NSW; Shepparton, Swan Hill and Mildura in Victoria and Waikerie and Renmark in SA. A map of the FFEZ can be found at www.agric.nsw.gov.au/reader/4558

Description and Lifecycle

The adult Queensland fruit fly is about 7mm long, and reddish brown with yellow markings. Queensland fruit fly prefers humid conditions. In early spring over-wintering adult flies become active and the females lay eggs in suitably mature fruit. Infestation develops successfully in these fruits and from then onwards the fruit fly population builds up as successions of suitable fruit become available for infestation. By late summer-autumn the flies can be very numerous and readily infest any suitable unprotected fruit until the onset of cold weather in late autumn.

- ☑ Fruit colour prematurely around sting site
- ☑ Damage is caused by larvae feeding inside fruit and invasion by secondary fungi/rots
- ☑ Prefer warm moist conditions
- ☑ Remove fallen fruit from the orchard floor

The female lays several hundred eggs during her lifetime. She lays about six eggs at a time about 3 mm deep in the fruit. In 2 or 3 days tiny larvae (maggots) hatch from the eggs and burrow through the fruit. They develop through three larval stages and are about 9mm long and yellowish when fully grown. When fully fed the larva pupates, usually in the soil beneath the tree.

The larval and pupal stages each take about 9 days to several weeks, depending on temperature. At least a week elapses before the newly emerged adult female lays eggs. The adults can live for many weeks and the females continue to lay eggs. There may be five or more overlapping generations during spring, summer and autumn.

Fruit fly 'stings'
The egg-site punctures in the fruit are referred to commonly as stings. To identify them, make a shallow cut through the skin and look with a lens for the egg cavity containing eggs or the remains of hatched eggs. In citrus the sting mark may be a brown depressed spot, or have only a vague, bruised appearance; on green citrus fruit the skin colours prematurely around the sting.

Damage to fruit
Infested fruit usually falls from the tree as a result of the activity of the larvae in it. The style of damage by fruit fly larvae tunnelling in fruit varies with the type and maturity of the fruit, the number of the larvae in it, and the weather. Frequently citrus fruits, although stung, do not develop larvae, but the stung fruit sometimes fall.

Control of Queensland Fruit Fly

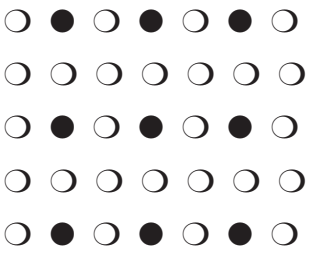
In districts where QFF occurs, harvest fruit as early as possible. Fruit fly populations increase as the season advances, and fruit becomes more attractive to the egg-laying females as it becomes riper on the tree.

Traps
Traps are used to monitor male fruit fly populations in orchards. The lures in the traps attract only the male fruit fly, which are then killed. The traps are effective and convenient for detection of fruit fly but they do not control it. There are a number of other fruit flys that are often captured in these traps such as Island fly and Callantra. These are not pest fruit flies. Traps can be purchased from your local Agricultural Supplier.

Baits
Bait mixture is prepared using an attractant (protein source) and an insecticide. Female flies are attracted to the protein which they require for egg maturation. As they feed they are killed by the insecticide. Bait spray components include the insecticides maldison or chlorpyrifos and yeast autolysate as the attractant. Bait mixtures should be applied according to Label directions which is normally to the lower foliage and skirts of trees and not to fruit as it can cause fruit burn. Baiting is more effective when carried out in the early morning when flies are most active.

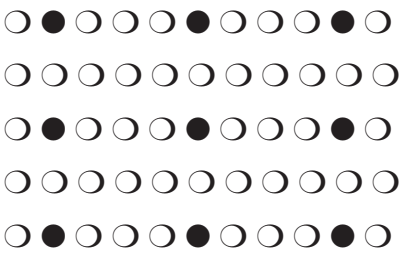
For information on registered chemicals, rates, type of protein and conditions refer to Infopest, the APVMA website, your local chemical reseller or agricultural advisor.

Application of Baits
It is recommended that about 50-100 mL (use the lower rate on smaller trees) of the bait be applied to the foliage of every second tree in every second row:



● = baited trees.

For double plantings, bait every fourth tree in every second row:



Baiting should commence at least 6 weeks prior to ripening. Apply weekly or after heavy rain as a splash bait when fruit fly are active. Baiting is more effective when carried out in the morning when the fruit flies are most active. It is important not to get bait mixture on fruit as it can burn fruit.

Cover Sprays
Registrations also exist for the chemicals dimethoate and fenthion for cover sprays for Qld fruit fly control in citrus. Cover sprays are not normally cost effective or necessary in treating large commercial plantings of citrus trees. However, in areas of high fruit fly pressure cover sprays are sometimes used.
N.B. Dimethoate may damage some varieties of lemon eg. Meyer lemons.

Orchard Hygiene
Orchard hygiene is an important supplement to baiting. Make sure you:

- ☑ remove unwanted fruit trees from around sheds, houses and along boundary fences;
- ☑ keep all house trees free from Queensland fruit fly;
- ☑ remove all late hanging fruit missed during harvest.
- ☑ remove fallen fruit;
- ☑ maintain good orchard hygiene.

THRIPS

- ☑ normally prefer protected sites (where fruits touch or leaves touch fruit);
- ☑ cause surface scarring to fruit and leaves;
- ☑ prefer dry warm conditions.

Summary of Main Thrips Species Affecting Citrus

Pest	Region	Appearance and damage	Occurance, conditions and monitoring
Scirtothrips	SE Qld, Northern NSW	Feed on leaves, shoots, blossoms and young fruit causing ring scarring and scurfing on fruit surface.	Prefers protected sites between touching fruit and under calyx. 6 generations/year. Monitor in spring.
Megalurothrips	SA, Vic, Southern NSW	Feeds on young fruitlets causing ring scarring and scurfing and rind discolouration.	Prefers sheltered sites. 6 generations/year. Monitor spring and autumn.
Citrus rust	Coastal Qld and NSW	Feeds on fruit and leaves causing brown rusty patches.	Prefers protected sites where leaves and fruit touch. 2 generations/year. Monitor summer-autumn.
Greenhouse	WA and Coastal NSW	Feeds on fruit and leaves causing scarring. Also present are black spots of excreta.	6 generation/year. Monitor October-March.
Plague	Coastal NSW and Qld	Feeds on blossoms and leaves causing brown blisters and petal browning.	12 generations/year.

MEALY BUGS

- ☑ have a waxy/mealy covering which is difficult to wet;
- ☑ normally on fruit or leaves;
- ☑ produce honey dew;
- ☑ sooty mould present;
- ☑ prefer sheltered sites and can hide underneath calyx on fruit;
- ☑ prefer warm humid conditions;
- ☑ cause downgrading of fruit quality;
- ☑ ants must also be controlled.

Summary of Main Mealy Bug Types Affecting Citrus

Pest	Region	Appearance and damage	Occurance, conditions and monitoring
Citrophilous	NSW, Vic, SA	Oval, white waxy on fruit and leaves	3-4 generations/year. Monitor November-June.
Longtailed	Qld, NT, NSW, Vic, SA	Oval, white and waxy with a long tail on fruit and leaves.	3-4 generations/year. Monitor November-May.
Citrus	Qld, NT, WA, Coastal NSW	Oval, white and waxy on flowers, fruit, leaves and twigs.	3-5 generation/year. Monitor November to May.
Other: Spherical Ragtrococcus	 Nth Qld Coastal NSW and Qld	 November-May December-March	

OTHER PESTS

Summary of Other Pests Affecting Citrus

Pest	Region	Appearance and damage	Occurance, conditions and monitoring
Citrus aphids	All	Black aphids feed on young flush growth causing deformed flowers, shoots and leaves *Sooty mould	25-30 generations/year. Present all year round but most abundant in spring and autumn. Prefer mild moist conditions. Extreme hot and cold conditions kills aphids.
Citrus blossom midge	SE, Qld and Nth NSW	Larvae feed on flowers and buds prior to opening destroying them.	12 generations/year. Monitor in spring.
Gall wasp	Qld, NSW	Wasp lays eggs in young twigs and the larvae burrow into the bark causing it to swell and form (galls) which can cause die-back of branches/twigs.	1 generation/year. Monitor August-December.

Photo by April Winchel

Aphids feed on new growth and also produce honeydew

Galls on branches caused by Gall wasp

NEMATODES

Nematodes are small microscopic worms, some of which are parasites of citrus. The most important is the citrus nematode. Other species which cause damage are the root lesion nematode and the stubby root nematode.

Citrus Nematode (*Tylenchulus semipenetrans*)
The larvae pierces the citrus root and buries its head into the root. Saliva released from the nematode causes the root to swell impeding the uptake of water and nutrients by the root. This in turn reduces tree yield and if infection is severe (over a long time) tree death may even occur.

Rootstocks have differing tolerances to citrus nematode. For example P. *trifoliata* is highly resistant whilst Rough lemon is highly susceptible. (See the Rootstock Section of this manual for more information.)

Citrus nematodes cannot be seen with the naked eye. Soil and root samples can be used to detect the presence and number of nematodes. However soil moisture conditions can affect nematode populations. Samples need to be submitted to a laboratory that undertakes nematode diagnosis. Take samples from around 20 sites to form a composite sample. The sample size for soils is 500 grams and for roots 100 grams.

Roots that have been attacked usually have a dirty, gritty appearance when the soil is shaken from them. This is because the soil tends to cling to the sticky egg masses produced by the female nematodes.

- ☑ use rootstocks tolerant to nematodes;
- ☑ cover crops and organic matter may improve natural biological control organisms in the soil;
- ☑ be careful not to bring nematodes into new areas on the roots/soil of nursery trees;
- ☑ in replant sites plant cover crops and spell the ground for several years before replanting.

SNAILS

There are numerous species of snails that occur in citrus orchards. Some cause damage to fruit and leaves whilst others tend to feed on decaying organic matter in the leaf litter and on weeds and grass in the interrow sod.

Photo by April Winchel
Leaves eaten by snails

Common Garden Snail
Snails feed mostly at night and in the early morning, prefer cool damp conditions and are most active in autumn, winter and spring. They become dormant in hot dry weather and seal the opening of their shell and shelter in leaf litter and the crotches of trees.

Damage
Snails chew the fruit, leaves and young twigs of trees leaving holes and scarring the plant tissue.

Control
Trees should be skirted to limit the movement of snails from the ground into the trees. The trunks and lower parts of trees can be sprayed with copper in autumn to repel snails. To check for the presence of snails in the orchard place a large sheet of cardboard under trees. Check underneath the cardboard the next day as snails will tend to shelter underneath.

Other Snail Species
Some snails are a quarantine risk to overseas export markets particularly in the southern citrus growing regions of NSW, SA and VIC. In these areas the following species are of importance, the small brown snail, common white snail, white Italian snail and pointed snail. The small brown snail has been found on fruit (oranges). The common white snail, pointed snail and white Italian snail tend to climb up trees and other structures such as picking bins, fence posts and farm machinery. In this way they can easily be transported around farms, regions and into packing sheds. Good harvesting, and postharvest handling and packing procedures need to be implemented to avoid snails being on fruit and in and on cartons, pallets and containers.

- ☑ Skirt trees
- ☑ Store bins on bare ground
- ☑ Snails prefer cool damp conditions
- ☒ Don't leave bins in the orchard overnight
- ☒ Don't pick fallen fruit
- ☒ Don't let weeds get too tall in the orchard

Key References

Citrus Pests and their Natural Enemies. Integrated Pest Management in Australia. Edited by D. Smith, G. A. C. Beattie and R. Broadley. 1997.

The Good Bug Book. Edited by R. Llewellyn. 2002.

Hardy, S. **Pest and Disease Management Guide for Coastal Citrus in New South Wales**. NSW Agriculture 1995.