

Scale insects

A difficult problem that can be managed

Background

Scale insects refer to a large group of insects within the super family Coccoidea. There are more than 20 families of scale insects world-wide including hard or armoured scales (family Diaspididae), soft scale (family Coccidae), ground pearls or margarodid scales (family Margarodidae), mealybugs (family Pseudococcidae), felt scales (Eriococcidae) and other smaller groups, e.g. cochineal insects (family Dactylopiidae). While all scale insects are basically a sap-sucking sack, there is a surprising amount of diversity in the biology of these insect groups.

This pest management plan covers the biology of the most common scale insects likely to be encountered in production nurseries in Australia, (i.e. Coccidae, Margarodidae and Eriococcidae). Refer to the [mealybug factsheet at the NGIA website](#) for the biology and management of this group specifically. Management of all scale insects share many common strategies, and therefore is only covered once. Additional management strategies and recommendations are made for specific groups, e.g. hard scales, where necessary. This plan is necessarily general, providing information typical of each scale insect group; detailed information on each scale species is not possible here. It is recommended to have scales encountered in your nursery identified to facilitate the management of the pest more specifically. Identification is particularly important when the infestation is widespread, when management actions have failed or when scale infestations reoccur frequently. Furthermore, some species are serious pests overseas, but are not present in Australia.

Generalised biology of all scale insects

All scale insects have a similar basic biology, though exceptions occur. Scale insects are sack-



Fig. 1. Pine needle scale (*Chionaspis pinifoliae*) close up and dieback symptoms, photo by J. Hanson and S. Tunnock (insert), both USDA Forest Service, Bugwood.org

like and often do not have functional legs. The term 'scale' refers to a substance secreted over the back of the insect. In most cases, adult females are sedentary and do not move. Most species lay eggs underneath their body (Fig. 2), though some lay live young. Some species are parthenogenetic, meaning

that they can reproduce without mating, others are hermaphroditic, e.g. some species from the genus *Icerya* have both male and female reproductive organs. Females are relatively long-lived, perhaps surviving a number of weeks or months under good conditions. Their main role is to reproduce and they do this very well, often being able to lay hundreds of eggs over their lifetime.

Males, when they occur, are very different in appearance to females (Fig. 3). They are generally smaller than females and appear superficially similar to whiteflies or gnats. Similar to flies, they only have one pair of functional wings; their hindwings are much reduced. They always have functional legs, but some species do not have any wings. Males do not feed, are short lived and mainly function to mate with females.

First instar nymphs (that either hatch from eggs or are live born) are called crawlers. Crawlers are the main means that scale insects are naturally dispersed. They are generally very small, being about 0.5-1mm in length, have functional legs and antennae. They are very light-weight and can disperse with the wind easily. Some species have been reported to be phoretic, meaning the crawler attaches to an insect and 'hitch-hikes'; some species attach to male individuals, e.g. some species from the genus *Cystococcus*.

After moulting to second instar, most scale insects become immobile for the rest of their life; their legs are reduced or absent. They grow in size, but are similar in appearance to females. Nymphal females have two or three nymphal instars before becoming an adult. Males always have four nymphal instars; the last of which is metamorphic and called a pupa.

All scale insects excrete honeydew, which is basically plant sap, high in sugar. Ants may attend scale insects, collecting honeydew. Honeydew is also dropped or shot away from the body. Black sooty mould often grows on leaves that have received honeydew.

Typical damage caused by scale insects

Scale insects feeding on young, growing tips can cause distorted foliage. Feeding on leaves may cause them to yellow and plants may appear water stressed. Heavy infestations can cause stems and branches to dieback; unhealthy plants may die. Scales present on fruit may cause them to be blemished or distorted, particularly if infestations occur when fruit are developing. A small number of species induce ornate galls in their host plants (see section on felt scale).

As mentioned above, honeydew often causes the growth of black sooty mould, which can be extremely

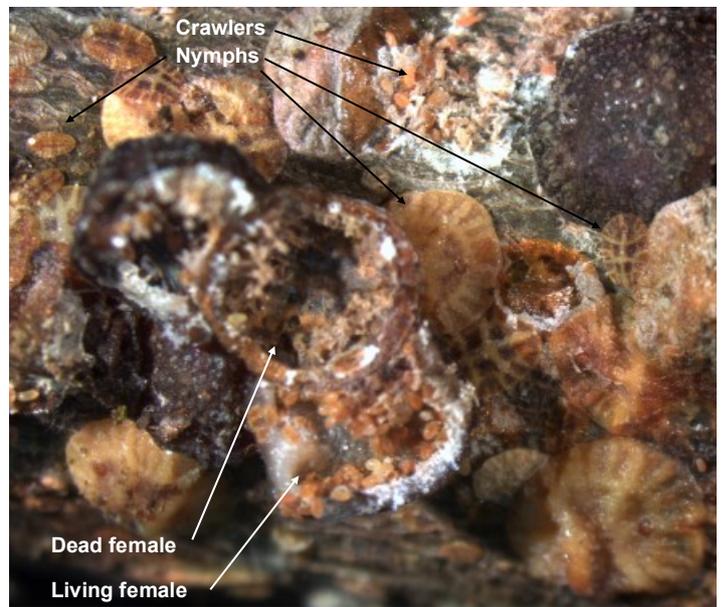


Fig. 2. *Saissetia* sp. scale insects illustrating female and nymphal individuals (above). Close up of over turned *Saissetia* female with eggs present under her body (middle) illustrating that the outer covering is connected to its body. Hard scale (below) shows oriental scale with their brown, circular cover and the yellow bodies housed underneath (not connected to the cover).

unattractive and may cause plants to be unsaleable. Black sooty mould is superficial and can sometimes be removed with some fungicide applications, but is only recommended after scale insects have been eradicated.

Soft scale (family Coccidae)

Soft scales are probably the most commonly encountered species of scale insect in production nurseries (refer to Table 1). Many species produce a thick convex wax layer, but others do not. Most soft scales present in Australia are native. A minority of species are introduced and are important pests of ornamental, fruit and vegetable crop plants. Soft scale insects come in a variety of shapes, colours and sizes. Some are flat and oval, others are globular, hard and highly convex or lobed. Scales can range in colour from bright pink, to black, brown or white. Some species have legs present, others do not; in most cases they are non-functional except for crawlers.



Fig. 3. Male scale insect mating, Photo by L. Graney, Bartlett Tree Experts, Bugwood.org

Table 1. Soft scales (family Coccidae) that may be commonly found in production nurseries.

Common and species name	Brief description	Geographic regions	Host range
<i>Saissetia</i> spp. – <i>S. coffeae</i> , <i>S. oleae</i> and <i>S. miranda</i> . Common names include black scale, black shield scale, brown olive scale, citrus black scale, olive soft scale, hemispherical scale, coffee scale, mexican black scale and many others (Fig. 2).	Brown to black, convex scales. Nymphs often have light and dark patches or bands.	Key pests in Qld, NSW, NT, Vic and WA, minor pest in SA and Tas	Mostly hardwood plants from more than 20 plant families, mainly Moraceae, Myoporaceae, Myrtaceae, Oleaceae, Rosaceae and Rutaceae including such species as apple, apricot, ash, citrus, daphne, fig, hibiscus, holly, magnolia, oleander, olive, passionfruit, pear, photinia, pistachio, plum, poplar, quince, tamarisk and many others.
Pink wax scale: <i>Ceroplastes rubens</i> (Fig. 4).	Edges are flattened with convex and globular hump in the middle. Light to bright pink, sometimes very pale. Often with white lobes.	Key pests in NSW and Qld, minor pest in NT, Vic and WA	Reported from over 80 plant families, mainly Anacardiaceae, Apocynaceae, Araliaceae, Musaceae, Myrtaceae, Rutaceae and Sapindaceae including avocado, banana, citrus (particularly mandarin), coffee, custard apple, fern, frangipani, holly, ivy, ixora, lilly pilly, mango, pittosporum and many other species.
White wax scale, white scale, citrus white scale: <i>C. destructor</i>	White and globular, often with dark circular areas in the middle or at the edge.		Reported from over 15 plant families, mainly Asteraceae, Rosaceae and Rutaceae including acacia, avocado, citrus, coffee, dodoneae, gardenia, guava, hibiscus, lilly pilly, persimmon, rosemary, stone fruit and other species.
Soft brown scale: <i>Coccus hesperidum</i> (Fig. 4).	Discoid, relatively flat. Mostly light brown and slightly transparent, with some dark patches.	Key pest in Qld, NSW, NT and Vic, minor pest in SA, Tas and WA	Reported from over 50 plant families, mainly Anacardiaceae, Caesalpiniaceae, Caricaceae, Hydrangeaceae, Malvaceae, Myrtaceae, Pinaceae, Rosaceae, Rubiaceae, Rutaceae and Solanaceae including blue spruce, citrus, coffee, fern, gardenia, hibiscus, hydrangea, lychee, mango, Moneterey pine, orchid, palms, papaw and many other plants.
Black scale or hibiscus shield scale: <i>Parasaissetia nigra</i>	Circular to elongate, black to dark brown; younger nymphs lighter brown. Convex bodies.	Key pest in Qld, NSW and Vic, minor pest in NT, SA and WA	Reported from over 20 plant families, mainly Anacardiaceae, Apocynaceae, Araceae, Euphorbiaceae, Myrtaceae, Rutaceae and Sapindaceae including avocado, cassava, citrus, ficus, frangipani, guava, ginger, hibiscus, lillypilly, mango, poinsettia and many other plants.

Hard or armoured scales (Family Diaspididae)

Hard scales are another very commonly encountered group of scale insects in production nurseries. This group differs from most other scale insects in that the waxy 'scale' produced by the insect is not connected to the soft body (see Fig. 2). In other words, the scale insect lives underneath a protective cover. In contrast, soft scales and most other scale insects are directly connected to their protective covering. This has implications for chemical control.

As hard scales moult, the armoured covering secreted by the insect gets bigger. As a result, the covering of hard scales occurs in concentric rings or oval lobes. However, crawlers do not have a covering. This is only produced when they moult to second instar. Hard scales are all relatively small, often no more than about 3mm in diameter. In general, they are earthy colours – black, brown, grey or white, though exceptions occur.

Many different species can occur on nursery stock (refer to Table 2) including red scale, oriental scale, oleander scale, white louse scale, rose scale, fern

Table 2. Hard scales (family Diaspididae) that may be commonly found in production nurseries.

Common and species name	Brief description	Geographic regions	Host range
Latania scale: <i>Hemiberlisia lataniae</i>	Light to dark brown, darker in the centre. Mostly concentric circles, sometimes off-centre.	Mainly found in Qld and NSW. May be found in NT and WA.	Reported on over 25 plant families, mainly, Actinidiaceae, Anacardiaceae, Arecaceae, Fabaceae, Lauraceae, Moraceae, Myrtaceae, Proteaceae, Rosaceae, Rutaceae and Sapindaceae including avocado, banana, grape, grevillea, hakea, kiwifruit, liquid amber, macadamia, mango, palms, pawpaw, poplar, privet, pear, plums, quince, Wollemi pine and many other plant species.
Oleander scale: <i>Aspidiotus nerii</i>	Similar to Latania scale, but less regular in shape and lighter in colour.	Key pest in Qld, but also found throughout, NSW, Tas and Vic. May also be found in WA, NT and parts of SA.	Reported on over 40 plant families, mainly Araliaceae, Arecaceae, Aucubaceae, Elaeocarpaceae, Ericaceae, Euphorbiaceae, Fabaceae, Grossulariaceae, Mimosaceae, Moraceae, Myrtaceae, Orchidaceae, Proteaceae, Rutaceae, Sapindaceae and Zamiaceae including, acacia, boxwood, citrus, eucalyptus, ferns, grape, ivy, macadamia, macrozamia, oleander, olive, orchid, persimmon and many others.
White louse scale: <i>Unaspis citri</i>	Oval and elongate. White lobed section with a dark brown region on one end.	Key pest in Qld and NSW, minor pest in NT and Vic.	Reported on only 2 plant families Chenopodiaceae and Rutaceae, mainly on citrus.
Rose scale: <i>Aulacaspis rosae</i> (Fig. 4)	Smaller individuals with elongate, white scale. Adults circular. Both have darker brown area at one end.	Key pest in Vic and Tas, minor pest in NSW	Blackberry, loganberry, raspberry and rose.
Fern scale: <i>Pinnaspis aspidistrae</i>	Similar to rose and white louse scale, but adults are more elongate.	Minor pest in Qld and NSW	Reported on over 15 plant families, mainly Arecaceae, Aspleniaceae and Polypodiaceae including many fern and palm species, but also can infest Chinese hibiscus, citrus, croton, cycads, dracaena, geranium, mango, orchids and African violet.
San Jose scale: <i>Diaspidiotus perniciosus</i> (Fig. 4)	Dark brown and produces regular symmetrical to slightly asymmetrical concentric circles.	Minor pest in Qld, Vic and WA	Mainly plants from the family Rosaceae in Australia, but many other host plants from other families have been reported overseas. Main hosts are pome and stone fruit, rose, berries and quince but may also include a large number of minor hosts including aloe, citrus, daphne, eucalyptus, ficus, periwinkle and many other species.
White palm scale: <i>Pseudaulacaspis eugeniae</i>	Mainly white or off-white, oblong scale with a small dark brown region at one end.	Minor pest in Qld, NSW, Vic, SA and WA	Over 10 plant families, mainly Arecaceae, Lomandraceae, Magnoliaceae, Moraceae, Myrtaceae and Proteaceae including many palm species, banksia, eucalyptus, ficus, leptospermum, lomandra, melaleuca and many other species.
Red scale: <i>Aonidiella aurantii</i>	Orange, brown or red, roughly circular scale.	Major pest in Qld, NSW and NT, Vic and WA. Minor pest in SA.	Over 50 plant families, mainly Arecaceae, Cucurbitaceae, Euphorbiaceae, Fabaceae, Moraceae, Rosaceae and Rutaceae including most citrus, olive, passionfruit and squash.
Oriental scale <i>A. orientalis</i> (Fig. 2)	Light orange to brown, roughly circular scale	Major pest in Qld, NT and northern WA.	Over 60 plant families, mainly Apocynaceae, Arecaceae, Caricaceae, Meliaceae and Solanaceae including banana, camelia, citrus, dracaena, guava, frangipani, oleander and pawpaw.



Fig. 4. Soft scales, pink wax scale (top left), soft brown scale (top right - photo by L. Ingram, bugwood.org), black scale (middle left - photo by Central Science Laboratory, Harpenden, Bugwood.org). Hard scales, rose scale (middle right - photo by USDA Agricultural Research Service, bugwood.org) and San Jose scale (bottom right - photo as previous). Cottony cushion scale (bottom right - photo by L. Ingram, bugwood.org).

scale, latania scale, San Jose scale, white palm scale and many others.

Margarodid scale insects (family Margarodidae)

Scale insects from the family Margarodidae are quite diverse. Species from this family are commonly known as cottony cushion scales, giant coccids, giant scales/mealybugs, giant wooly mealybug and ground pearls. Most species from this family are native to Australia, only a few are introduced and these are unlikely to be pests of nursery stock. There is a great deal of variation in the appearance of margarodid scale insects. Some species are very large, thick, oval, sculptured insects with distinct antennae, sometimes reaching 2 cm in length, e.g. *Monophlebulus pilosior*. Other species are ground dwelling, pearl-like insects. Margarodids often have orange or yellow regions on their body with white wax that can be wool-like or more solid in nature. Males are relatively large and may be colourful, grey or brown; they typically have large wings and long antennae. This group occurs in all regions of Australia.

The most well-known margarodid is cottony cushion scale, *Icerya purchasi*, though other species may be present on a range of nursery plants, particularly Australian natives (Fig. 4). Cottony cushion scale has a bright orange to brown body that is often covered in white wax. It produces a large egg mass that is fluted and resembles a hanging beard (Fig. 4). Each egg mass may have up to 600-800 eggs and there are probably 2-3 generations per year. It is present in every state and territory in Australia, but is more likely to be a pest in warmer climates. In Australia, most host plants are from the families Fabaceae or Rutaceae, e.g. citrus and *Hardenbergia*, but many other host plants may sometimes be infested. Like mealybugs, cottony cushion scale and many margarodid species can walk and are potentially mobile their entire life.

Felt scale (Family Eriococcidae)

Felt scales are mostly pests of Australian native plants, including genera such as *Eucalyptus*, *Leptospermum*, *Callistemon*, *Grevillea*, *Araucaria*, *Casuarina*, *Banksia* and *Macadamia*. Most felt scales are about half a centimetre long or less. There is a great deal of variation in their appearance. Some appear similar to mealybugs, being grey to white with a waxy covering, e.g. *Eriococcus araucariae* on hoop pine (Fig. 5). Whereas, *E. coriaceus* on gum trees is oblong, brown and has a distinct black to dark brown region on one end. Other species produce ornate galls on their host, e.g. *Apiomorpha munita* on *Eucalyptus* (Fig. 5); galls produced by females of this species appear significantly different from that produced by males. If this group of scales is regularly encountered, it is recommended to have it identified to access more specific information on their biology. Management



Fig. 5. Eriococcidae, gum tree scale (*Eriococcus coriaceus*) (above - photos by L. Ingram, Bugwood.org) and close-up of *E. araucariae* (middle - photo by USDA ARS, Bugwood.org); Galls produced by *Apiomorpha* sp. (below - photo by Lesley Ingram, Bugwood.org)

actions can then be tailored specifically. This group occurs in all regions of Australia.

Monitoring

Monitoring is essential for all pests, diseases and general plant health. Monitoring provides essential information for making management decisions. Monitoring will detect the presence and numbers of scale insects, their natural enemies (predators and parasitoids) and other pests and diseases. Regular monitoring can be used to determine the change in numbers, i.e. whether populations are increasing or decreasing. This information is extremely valuable and informs how effective each management action has been.

Monitoring for scale insects should include visual observations including turning over leaves, looking for black sooty mould and the presence of ants on plants. Plants that have scale insect damage, or are otherwise unhealthy, should be examined more carefully. Use a x10 or x20 hand lens, where necessary, and examine stems, leaves and other areas that are prone to scale insects.

Once scale insects have been observed, check for the presence of egg masses, crawlers and parasitised individuals; this may involve removing female scale insects as eggs are often laid, concealed, under their body. This is important as it indicates that populations will increase quickly if management actions are not taken. The proportion of different life stages present, most notably crawlers, may also change the exact actions taken; crawlers are susceptible to pesticides, but other stages are more tolerant.

Parasitised individuals are most easily recognised by observing a circular exit hole on the back of the scale. This indicates that that individual had been parasitised. For hard scales, remove the protective covering of a subset of individuals and observe if there is a scale present or a parasitoid (top insert, Fig. 6). Populations with a large proportion of parasitised individuals should be monitored carefully to ensure that pest numbers are declining.

Management of scale insects

Management of scale insects should focus on preventing infestations and managing populations before they cause economic loss. Scale insects are notoriously difficult to control once established as they are often tolerant to pesticides or protect their offspring from contact. Fortunately scale insects can be managed effectively if nursery managers are proactive. These management actions include cultural, chemical and biological control options.

Cultural management practices minimise infestations by scale insects.

- Always inspect new stock carefully, particularly host plant species that are regularly infested with scale insects (and other pests and diseases). Inspect all plant parts, including roots, for any signs of pests.
- Monitor plants regularly. Plant species that are prone to scale insects (or other pests) should be monitored more consistently.
- Only propagate from clean mother stock plants. In other words, do not take cuttings from plants that have scale insects present. Even one individual can multiply increasing the problem significantly.
- Remove plants with heavy infestations, taking care to reduce spread of scale insects while doing so. If infestations are limited to a particular branch and it can be pruned, remove this plant material and monitor closely to ensure the rest of the plant is clean.
- Remove crop debris and disinfest the growing area after removing a consignment of plants that have had scale insects with a suitable product, e.g. farmcleanse, bleach or similar product. Scale may survive for weeks on crop debris and in egg masses that have fallen off plants. This practice will also reduce other pests and diseases that may be lingering from previous crop cycles.
- When only a small number of plants are present with a low rate of infection, squash scale insects and egg batches. Squashing large numbers of individuals may irritate skin, but can be avoided by using rubber gloves. The presence of a small number of individuals should prompt regular and rigorous inspections of the consignment.
- Avoid movement of infested plant material within the growing area.
- Avoid staff movement in areas known to be infested with scale insects and other pests. If necessary, disinfest clothing and equipment after working in such areas.
- Provide an optimal growing environment, including appropriate nutrition, water, growing media and other conditions; weak plants are more susceptible to damage at lower populations of pests.
- Control ants as they spread crawlers and protect scale insects from natural enemies.
- Thoroughly disinfest recycled pots to avoid transferring eggs and nymphs from crop to crop.
- Keep the growing area and surrounds free of weeds.

- Ensure adequate plant spacing. This allows greater air movement and increases pesticide coverage. It also reduces ideal environments for scale insects to develop and increases the ease of detection.

Biological control

There are a number of natural enemies that can manage scale insects including commercially available predatory insects and naturally occurring parasitoid wasps and predators. There are also a range of fungi and bacteria that may infect and kill scale insects, although these are less likely to substantially reduce populations unless they become very abundant. Almost all pesticides will negatively impact beneficial insect populations (i.e. predators and parasites). It is recommended to seek advice from the biological control agent producer prior to releasing a predator for the first time so that their release is optimised. If pesticides have been applied, ensure that a sufficient time period elapses before releasing beneficial insects (refer to Table 3 as a guide). Additional information is also available online or from the biological control agent producers.

Cryptolaemus - *Cryptolaemus montrouzieri*

Cryptolaemus (pronounced: Crip-toe-lee-mus mon-tro-zere-ee) is an Australian native ladybird that is widespread and mainly feeds on mealybugs and felt scales (particularly on hoop pine). It may also feed on some soft scales. It is commonly known as the mealybug destroyer. Both larvae and adults feed on mealybugs, hence its common name. Adults are about 4mm long, oval in shape with an orange head and black wing covers. Adults and small larvae only feed on eggs and very small mealybug nymphs; larger larvae feed on larger mealybugs including adults. Larvae are covered with white waxy filaments, making them very similar in appearance to mealybugs, but *Cryptolaemus* larvae are more mobile and appear to have banding along their body (Fig. 6). When carefully removed from the plant, they can be turned over to see their well-developed legs and chewing mouthparts. Females can lay up to 10 eggs per day directly into mealybug egg masses and up to about 500 eggs over their lifetime. The lifecycle of *Cryptolaemus* takes about 4-7 weeks from egg to adult, depending upon temperature and food source. They will also consume some soft scales when more preferred food is not available. *Cryptolaemus* is commercially available from Bugs for Bugs.

Green lace wings – *Mallada signata*

The green lacewing has a relatively wide host range, feeding on aphids, spider mites, various scales, mealybugs, moth eggs and small caterpillars as well as whitefly species. Pollen and nectar can also be ingested. Larvae, but not adults, are predacious. Adults have a green body and hold their transparent



Fig. 6. *Cryptolaemus montrouzieri* adult (above) and large larva (middle), photos by DAF; green lacewing (below - photo by Whitney Cranshaw, Bugwood.org).

wings tentlike over their body and feed on pollen and nectar. Females live for 3-4 weeks and lay up to 600 eggs. Almost all lacewing species are predators and often lay their eggs on thin white stalks with a bulbous white egg at the end; most species lay multiple eggs in the same area, most often in a straight or roughly straight line or in a horseshoe arrangement. Green lacewing larvae grow to nearly 1 cm in length before pupating and typically place the remains of their prey on top of spines protruding from their back. In fact, research suggests that green lacewing larvae with trash-packages are more active and forage more efficiently, while those without trash-packages are more likely to become inactive. After about 12 days, larvae pupate and emerge as adults about 9 days later. Females must be about 7 days old before laying their first egg.

It is well adapted to relatively warm conditions and very sensitive to persistent and or broad spectrum chemical applications, although 'soft' pesticides have a relatively minor negative impact on this insect. Green lacewing is commercially available from Bugs for Bugs.

Chilocorus beetles (*Chilocorus circumdatus* (red) and *C. baileyi* (blue))

There are two species of beetles commercially available that feed on a range of hard scales. Red chilocorus feeds on white louse scale, oleander scale, oriental scale and red scale (Fig. 7). Blue chilocorus feeds on oleander scale, oriental scale and a number of other species of hard scale. Both species are small (4-5 mm long) and helmet shaped. Larvae are elongate, light brown and have black spikes covering their body. Eggs are laid under the cover of scale insects. They prefer warm conditions, completing their lifecycle in about a month at 28°C and beetles live for about 4-8 weeks. They are very sensitive to insecticides, avoid releasing these species within two weeks of insecticide application. They are commercially available from Bugs For Bugs.

Aphytis species (*Aphytis lingnanensis* and *Aphytis melinis*)

These tiny, orange-yellow wasps (Fig. 7) are very similar in their biology; they are no more than about 1 mm in length. Wasps lay eggs into red scale, oriental scale and oleander scale. Adults live for about 2 weeks and may lay over 100 eggs. Larvae develop inside scale insects over about 2-3 weeks and emerge as wasps. Adults also feed on scale insects, increasing scale mortality. Both species are adapted to warm climates, with optimal population growth at 25-30°C, but *A. melinis* is able to tolerate slightly higher temperatures (up to 35°C, 38°C for short periods). These species are very susceptible to insecticide applications. *Aphytis lingnanensis* is



Fig. 7. Aphytis wasp ovipositing into a hard scale (above) and pupae that develop under the scale (insert), Chilocorus ladybeetle (middle) and larva (below). All by Denis Crawford, Graphic Science, except top insert (DAF).

available from Bugs For Bugs, *A. melinis* from Biological Services.

Other natural enemies

There is a large number of parasitoid and predator species that occur naturally that may feed on scale insects, particularly native scales. These include various species of lacewings, lady beetles and *Aphytis* wasps that are not commercially available. Other predators include certain predatory bugs, mites and beetles. Often these predators are small, appear superficially similar to scale insects and may feed from underneath the scale insect. Predatory bugs, mites and beetles are highly mobile and have the ability to search out prey. Native parasitoid wasps may also parasitise or otherwise feed on scale insects, particularly native species, e.g. various *Aphytis* and *Encarsia*. Wasps cut a circular exit hole to emerge from scale insects that they have parasitised (Fig. 8).



Fig. 8. *Saissetia* scale with an exit hole from a parasitoid wasp.

Chemical control

Scale insects are difficult to manage using pesticides alone. Contact products tend to slough off their waxy body and they may be tolerant to systemic products. If pesticides are to be used to manage scale insects it is recommended to apply contact products only when there is a high proportion of crawlers present. Crawlers are very susceptible to many pesticides, including oil based products. If high populations are present a systemic product will probably be required. If possible, apply in combination with an oil or detergent based product, but only if this will not cause a phytotoxic reaction. Also, consider modifying the way that pests are managed, such that monitoring is conducted more frequently; increase the use of cultural management options.

Consecutive weekly pesticide applications will almost always be required if using pesticides to manage scale

insects. Even then, total control may not be achieved. It is always recommended to rotate between active ingredients from at least three different mode of action groups. This will reduce the likelihood of inducing pesticide resistance substantially.

Pesticides will almost always significantly reduce predator populations. Some products can be active against predators for months after application, but have limited or negligible impact on pest populations after the initial application. Therefore, carefully consider whether it is necessary to apply pesticides, particularly when they have a long residual impact on beneficial populations. Green lacewing can be effective against a range of pests including many scale insects. *Cryptolaemus* may also be very effective against a range of soft scales. Predators effective against a

Table 3. Basic guidelines for managing scale insects with a combination of biological control and pesticides.

Scales absent	Low populations	Moderate populations	High populations
Continue monitoring. If a particular species of scale insect consistently attacks the plant during a particular time of year, release predators or parasitoids at preventative rates.	Release at normal rate weekly until 80% of scale insects are parasitised or consumed. If hot spots occur within otherwise low levels of whitefly, add high rates to the hotspot. Refer to high populations, right.	Release at high rates weekly until 80% of scale insects are parasitised or consumed. If the plant species is highly susceptible to damage, application of a low risk insecticide may be warranted prior to release.	Remove as much highly infested plant material as is feasible. Apply a low risk insecticide (e.g. products with the active ingredients pyriproxyfen, buprofezin, Spirotetramat) to knock down scale insect numbers to a manageable level. Be aware of how long the product will be active against the biocontrol agent. Release when safe and numbers are low.

range of hard scales are also available that should be considered instead of applying pesticides.

With that said, there are a number of insecticides that are registered against scale insects relevant to production nurseries. Some products have a general nursery stock registration, others may only be registered on a subset of species grown in the nursery production sector. Table 4 summarises these registrations and minor use permits. Refer to the [mealybug factsheet](#) for registrations specifically against mealybugs. Always ensure that you read the label and that it fits your exact situation; not all active ingredients listed in Table 3 are registered in all states or on all nursery plants. Refer to the nursery [pesticide application best practice manual](#) for more information. Also refer to the [APVMA](#) or [Infopest](#) for most up-to-date registrations and minor use permits.

Recommendations

The following recommendations can be used as a guide, but may require modification based on the plant species infested, scale insect involved, environmental conditions and other factors. It is always recommended to have the scale insect identified as this may allow for use of specific biological control agents, more detailed information on pesticide efficacy and the range of known plant species that may also be infested at the nursery.

Put in place management strategies discussed in the management section above. In particular, remove as much heavily infested plant material as possible. Where predators can be used to manage populations of scale insects refer to recommendations in Table 3. Always talk to the biological control agent producer for advice on how to optimise release beneficials, particularly when applying for the first time.

There are a range of factors that may prevent successful release of beneficial insects. The predator may not feed on the scale insect species infesting the plants. Environmental conditions may prevent their successful release. This can occur during high summer heat, e.g. above about 35°C, or cold night time temperatures, below about 10°C. If the area of infested plants is very small, i.e. only a few square metres it may not be cost effective to apply predators. However, some products are available in

‘garden packs’ specifically for management of relatively small areas. In these cases, cultural management practices and pesticide applications are likely to be the major components of your management plan for scale insects. Refer to Table 4 for more detailed information on products registered for scale insects in Australia.

Where biological control is being practiced (either for scales or other pests) the following rotation is recommended:

- Spirotetramat
- Buprofezin
- Pyriproxyfen
- Fenoxycarb

Add an oil compound at label rates if feasible, particularly if crawlers are present.

Where biological control is not practiced and naturally occurring beneficial species are not to be conserved, the addition of the following products can be added to the rotation.

- 1B product (preferably a systemic product)
- 4A product
- Sulfoxaflor (see text below)
- Carbaryl (but only if the product will contact scale insects present)

The active ingredient sulfoxaflor is relatively new and has had limited research on the effects on parasitoids and predators. Where research has been completed it has shown that the product has moderately negative impacts, either causing direct mortality to early instar individuals or sub-lethal effects on adults, e.g. significantly reduced egg laying ability, life span or reduced feeding. However, specific research on species relevant to scale insect biological control in Australia has not been completed.

Further reading

Llewellyn, R. (Ed). 2000. *The Good Bug Book*, second edition. Integrated Pest Management Pty Ltd., Richmond, NSW.

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Table 4 Active ingredients registered against scale insects relevant to Australian production nurseries. Action C = contact, S = Systemic and T = Translaminar. Toxicity to beneficials is just a guide based on current information and some products may differ in their impact to beneficial populations.

Mode of action group	Active ingredient	Example product name	Registration information	Action ¹	Toxicity to beneficials ²
1A	Carbaryl	Bugmaster	Selected scale insects on oranges, lemons and mango.	C	H – 4+ weeks residual
1B	Chlorpyrifos	Lorsban	Selected scale insects on apple and pear, avocado, citrus, grape vines, mango and stone fruit (not cherries).	C	H – 2-4 weeks residual
1B	Diazinon	Diazinon	All scale insects on nursery plants and selected scales on certain fruit crops.	C	M-H – 2-3 weeks residual
1B	Dimethoate	Dimethoate	All scales on Eucalyptus, kurrajongs, flame trees and umbrella trees only in WA only.	S	H – 4+ weeks residual
1B	Maldison	Maldison	Selected scales on citrus, grape vine, all scale insects on hardy ornamentals, eucalypts and native plants.	C	H – 2-4 weeks residual
1B	Methidathion	Suprathion	San Jose scale on apple and pear, stone fruit, various scales on avocado, apricot, citrus, custard apple, grape, macadamia, mango, passionfruit, orchids; all scale insects on ornamental trees and shrubs in nurseries. Labels vary. All scales on lychee (PER14099) and persimmons (PER13694).	C	H – 2-4 weeks residual
1B	Omethoate	Folimat	Red scale on citrus only.	S	Probably H – 4+ weeks residual
4A	Acetamiprid	Crown	Scale insects including coffee scale, nigra scale, pulvinaria, but not white wax scale, on ornamental plants.	S	Probably M-H – 2-3 weeks residual
4A	Imidacloprid	Confidor, Merit, Suscon Maxi Soil	PER81707 All scale insects on nursery stock (for inclusion in potting mix only). Soft scales on ornamental plants, pink wax scale and red scale on citrus. All scales on magnolias (Initiator tablets). Labels vary.	S	H – 2-3 weeks
4C	Sulfoxaflor	Transform	Certain scales on citrus only.	S	Probably L-H - unknown residual.
7B	Fenoxycarb	Insegar	PER81707 All scales on nursery stock. San Jose scale on apple and pear only.	T	L-H – 1-3 weeks
7C	Pyriproxyfen	Admiral	Certain scales on citrus, mango and olive.	T	Probably L-M – 1-2 weeks residual
16	Buprofezin	Applaud	PER81707 All scale insects on nursery stock. Various scales on selected fruit crops.	T	L-M – 0-3 weeks residual
23	Spirotetramat	Movento	PER81707 All scale insects on nursery stock.	S	L – 0-1 week residual
NA	Paraffinic oil	Biopest paraffinic oil	Hard and soft scale on apple, all scales on pear, apricot, blueberry, olive, grape, cherry, plum, prune, pecan, avocado, kiwi, custard apple, mango, shade trees and shrubs and woody ornamentals, flowers and foliage plants. Labels vary.	C	L-M – 0-1 week residual
NA	Petroleum oils	Winter oil	PER81707 All scales on nursery stock. Most labels with selected scales on certain fruit crops, some with all scales on ornamentals.	C	L-M – 0-1 week residual
NA	Sulphur	Sulphur, lime sulphur	White louse scale on citrus and San Jose scale on apple and stone fruit. Labels vary.	C	Probably L-M – 1-2 weeks residual