Field Guide to Olive Pests, Diseases and Disorders in Australia

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Foreword

This document is a revision of the book Field Guide to Olive Pests, Diseases and Disorders in Australia published in 2007. This revision has been undertaken as part of the Hort Innovation-funded project OL17001 An Integrated Pest and Disease Management Extension program for the Olive Industry. In addition to this guide, there are a series of web-based tutorials and 1-2 page flyers on key pests and diseases as well as information on implementation of IPDM programs. These documents can be accessed on OliveBiz.

Arthropod pests and diseases are often key constraints to economic production of olives and olive products through their effects on both yield and quality. Apart from diseases caused by living organisms (pathogens), olive trees are also subject to disorders resulting from adverse environmental conditions and cultural practices. Australia is unique in that while it has a number of traditional, cosmopolitan pests and diseases, as well as several native species, it is free from a number of highly damaging exotic species. The industry is vulnerable to their introduction.

This document provides up-to-date information on most of the possible pests, diseases and disorders in Australian olives. This information has been revised in light of a 2018 national IPDM survey, and grower feedback at 10 field days conducted in 2018-2019 in all olive growing states. Apart from invertebrate pests and disease-causing organisms, many other symptoms of damage to plants and fruit were encountered which are likely the result of physiological and other disorders due to irrigation or nutrients. Similar to the original version, we have provided information on beneficial species, such as biological control agents. Furthermore, we have revised the section on exotic pests and diseases in light of recent overseas events. This section addresses the five top ranked threats to the olive industry in the Biosecurity Plan (2016).

Because of its electronic nature, we have been able to include more detailed information in this revised edition as well as more images than the original hard copy book.

As a result of the changing nature of pesticide registrations and permits for the Australian olive industry, we have not included this information. You are advised to regularly check the website of the Agricultural Pesticides and Veterinary Medicines Agency (www.apvma.gov.au) to maintain up-to-date information.

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Integrated pest & disease management

Integrated pest and disease management (IPDM), developed in the 1960s and 1970s, is based on ecological principles. It encourages reduced reliance on pesticides through the strategic use of a number of tactics in a harmonious way to keep pests and diseases below the level causing economic injury. It came out of the realisation that too heavy reliance on pesticides (particularly those with broad-spectrum activity) can cause major problems, notably:

- effects on human health and safety
- environmental contamination
- pesticide resistance in target and non-target organisms
- resurgence of secondary pests
- plant damage or yield loss (phytotoxicity)
- residues on fruit and products, with national and international consequences.

There is also general community concern about the use of pesticides, particularly on foods.

IPDM commonly utilises or encourages biological control through natural enemies such as predators, parasites, insect diseases and non-pathogenic antagonistic or competitive microorganisms. It also frequently involves control strategies to minimise pest and disease entry and their spread in space and time. Cultural controls include national, regional and on-farm biosecurity; manipulation of the field environment to discourage pests and diseases, such as opening tree canopies to increase air movement and reduce humidity; the elimination of alternative hosts for pests; or growing nectar- and pollen-producing plants to encourage natural enemies. IPDM may also involve the physical destruction of infested materials and the use of tolerant or resistant plant species, where available. Chemical pesticides are used judiciously, and thus play a supportive role.

The major components of IPDM systems are:

- identification of pests, diseases and natural enemies
- monitoring of pests, diseases, damage and natural enemies
- selection of one or more management options on the basis of monitoring results and action thresholds, from a wide range of pesticide and non-pesticide options

- use of selective pesticides targeted at the pest or disease—e.g., those that will interfere least with natural enemies, targeted only at infested trees or parts of trees
- continuous review of management success, and incorporation of new information and techniques.

Monitoring

The most important part of any pest and disease management system is monitoring. This is because the mere presence of a particular pest does not provide enough information for decision-making. The pest or disease may not be sufficiently widespread, or the population levels may not cause enough damage, to warrant undertaking management strategies.

Regular monitoring, with effective recording of the results, provides important information that helps in making decisions on whether and when action should be taken, and how effective actions have been. The first step in the development of a pest and disease management program is to concentrate on the most serious pests and diseases, and build up records about the times, locations and conditions where problems are most likely to occur. Because natural enemies play an integral role in the system, they also need to be monitored and recorded.

In commercial situations, monitoring programs need to be quick and efficient while still providing accurate and repeatable results. Monitoring can be undertaken by growers, trained employees or commercial pest scouts.

Monitoring commonly involves visual observations, usually based on sampling, and may involve actual counts, or the presence or absence of pests, diseases and their associated damage. Technologies such as satellite imaging, drones and robots with image analysis capacity are increasingly being used to gather plant health data. Other supplementary monitoring methods are coloured sticky traps (yellow is the most common, and attracts small, flying, insects such as thrips, aphids, fruit flies and male scale insects, as well as some beneficial species such as parasitic wasps), and chemical attractant traps that are often species-specific.

Yellow sticky trap used to monitor for olive fly in Italy

Monitoring methods

Monitor every grove (or block in large groves) at least monthly during the growing season. Monitor priority blocks (e.g. those with a high fruit load or with a history of pest or disease problems) more frequently. Divide large blocks into sub-blocks. On each sampling, select at least several rows within each sub-block in a semi-structured way. Sample different rows on each occasion, and combine detailed tree inspection with identification of infestations as soon as possible.

In larger groves, driving slowly down rows makes it possible to detect only high populations of pests and diseases that have already caused a significant level of damage or, in the case of black scale, produced a significant amount of honeydew. (Remember, though, that even when sooty mould is highly visible, it does not necessarily indicate active scale infestations.) Monitoring from a vehicle will also detect only advanced symptoms associated with severe root or limb disease, pesticide injury or nutrient imbalance.

Assessing individual trees is important for early detection of pests and diseases. Within the monitored rows, examine at least one tree in detail, more in long rows. Choose trees in a structured way so that, for example, you check a tree in the first third of the first checked row, then one in the middle third of the checked row, and one in the last third of the third checked row. The position of the checked tree within the row in each sub-block should change with each visit. For example, the next time, check a tree in the second third of the first checked row, then one in the last third of the second row, and so on.

Carefully examine individual trees from all sides and at all heights using a systematic approach. Inspect samples of twigs, flowers and fruit for the presence of pests, diseases or damage using a 10× hand lens (if you find hand lenses difficult, you can use a magnifying glass, but be aware that their magnification and therefore the quality of the observations are inferior).

Inspect trees for abnormal flower buds, and check for the presence of thrips by beating flower clusters onto a white or dark background, such as cardboard. Inspect fruit for the presence of fruit fly or other damage, as well as for symptoms of disease or deformity.

If scale or lace bug is detected, the life stage(s) should be assessed. Examine scale infestations carefully under magnification to determine the stage of scale development and the level of parasitism. Turn over adult scales to check for developing eggs or crawlers.

If a pest or disease is detected, check surrounding trees in the row and in adjacent rows to establish the extent of the infestation. Make note of the pattern of infection, which is the association of the disease or pest with:

- terrain (e.g. sheltered or exposed locations, low-lying areas)
- weather and aspect (e.g. prevailing wind direction, orientation to sun)
- tree characteristics (e.g. cultivar, tree age, part of tree affected)
- cultural practices (e.g. irrigation, fertilizers, pesticides, pruning, mulching).

Identification of disease pathogens is often more difficult, and if the symptoms are unclear, send specimens to a qualified plant pathologist for diagnosis.

Senior author using 10× magnifying glass to examine black scale

Recording data

Record date, tree identification and position, pest or disease name, extent of damage, pattern of infection, life stage and any parasitism. Records of pesticide applications, cultural practices and weather greatly help in interpreting monitoring data.

Action thresholds

Action thresholds are the levels of pests, diseases or damage at which a decision is made about the action to be taken; they normally take into account natural enemy activity. The decision also needs to take into account previous experience, predicted weather, projected yield and market prices, and grower preference.

Unfortunately, no specific action thresholds (requiring detailed research) have been determined for major olive pests in Australia, although they have been made for some of the same pests or diseases in different crops), or for olives grown overseas (such as impact of fruit anthracnose levels and olive fly damage on oil quality).

Once action is taken, follow up on its results by further monitoring, and by postharvest assessment of fruit and oil yield and quality.

Using this guide

The common pests, diseases and disorders in Australia are separated into 3 sections. Use the table below to determine the possible causes of symptoms on your tree; the pest, disease or disorder can then be found alphabetically in the specific section based on common name. Clicking on the name of each pest or disease will take you to the correct page.

	Common name of:		
Symptom	**Pest**	**Disease**	**Disorder**
Leaf yellowing & branch dieback	African black beetle Armoured scales Black scale	Charcoal rot Leaf mould Peacock spot Phytophthora Rhizoctonia Verticillium Wound canker	Tip death
Leaf spots, leaf discoloration & damage	Grasshoppers Lace bug Lt-brown apple moth Rutherglen bug Weevils	Leaf mould Peacock spot	Sooty mould
Leaf fall	Lace bug	Leaf mould Peacock spot	Problems with water and plant nutrition
Flower damage	Thrips	Anthracnose	
Fruit damage and rot	Armoured scale Green vegetable bug Fruit fly	Anthracnose Peacock spot	Apical end rot

Stem damage, galls and bumps	Cicadas	Crown gall Olive knot	Sphaeroblasts & oedema
Stem cankers & death		Phytophthora Verticillium Wound canker	
Root rotting and damage	African black beetle (larvae) Weevils (larvae)	Charcoal rot Nematodes Phytophthora Rhizoctonia	Clay panning or root plaiting
Tree blackening	Ants Black scale		Sooty mould

Beneficial species

In this guide, we have used the term beneficial species to describe the natural enemies of olive pests or diseases that may be observed in olive groves, and that give some level of biological control of the pests. These beneficial species may be either native or exotic, and a number occur naturally in groves. In such situations, they can be conserved and encouraged by environmental modifications, such as the planting of nectar- and pollen-producing cover crops (which can, unfortunately, also bring negative benefits: see Thrips p. 41) and the reduction in use of broad-spectrum pesticides. A number of beneficial species are mass-reared in Australia and are available for purchase (see Australasian Biological Control, www.goodbugs.org.au).

Host-specific natural enemies are discussed and illustrated along with their host pests. Many of these natural enemies are small (<2 mm) parasitic wasps (known as micro-Hymenoptera) in the superfamily Chalcidoidea, particularly in the families Aphelinidae, Chalcididae, Encyrtidae, Pteromalidae and Trichogrammatidae. Most members of these diverse families parasitise small arthropods, including scales, aphids and insect eggs. Many are parasitoids, i.e., they kill their host. Larger wasps found in groves belong primarily to the Braconidae, Ichneumonidae and Sphecidae, which prey on larger insects and spiders.

A number of species of ladybirds (family Coccinellidae) are also found in olive groves. Both immature (larval) and adult ladybirds eat soft-bodied insects. Two of the most common species are *Cryptolaemus montrouzieri* and *Hippodamia variegata*:

- *Cryptolaemus montrouzieri*, known as the mealy-bug destroyer, is a native species commonly found on trees infested with scale insects and honeydew.

- *Hippodamia variegata*, known as the white collared or spotted amber ladybird, is a European species. It was first recorded in Australia in 2000, and is now common and widespread. *H. variegata* feeds on aphids, thrips and insect eggs.

- Other ladybird species recorded in olive groves include orange-spotted ladybird, *Orcus australasiae* and transverse ladybird, *Coccinella transversalis*.

Other common predators are spiders, lacewings (see Olive Lace Bug, p. 36) and larvae (maggots) of hover flies (family Syrphidae). While these species eat a range of arthropods, their role and impacts in olive ecosystems are yet to be fully determined.

Top Adult ladybirds, *Orcus australasiae,* on olive leaf

Bottom Larva of ladybird, *Cryptolaemus montrouzieri*

From top LH

Ladybird (*Hippodamia variegata*)

Leafcurling spider (*Phonognatha graeffei*)

Adult syrphid hover fly

Larva syrphid hover fly

Adult green lacewing (*Mallada signata*)

Invertebrate pests

African black beetle, *Heteronychus arator* (Coleoptera: Scarabaeidae)

Size Larvae C shaped 25mm
Adults 10mm

Biology and damage There is one generation per year. The shiny black adults overwinter; they are soilborne but occur near the soil surface and are nocturnal. They mate and lay eggs in spring. Larvae are C-shaped with a brown sclerotized head and prominent black jaws, three pairs of well-developed legs with a white thorax/abdomen with a distended anal end. They are soilborne and are present from spring to mid-summer after which they pupate and emerge as beetles.

Adults feed on the bark of young trees near ground level up to about two years after transplanting. Damaged plants have flayed bark tissue near the soil surface; they may wilt and die. Beetles can cause extensive tree death in establishing groves. Larvae feed on organic matter and plant roots. They have not been reported to cause damage to olive trees.

Comments Check before planting for infestations of adults with pitfall traps or spade sampling. Buried grow guards prevent beetles feeding on newly planted trees.

The entomopathogenic nematode *Heterorhabditis zealandica* is commercially available for controlling black beetle larvae in turf.

Top African black beetle adult

Bottom African black beetle larva

Ants (Hymenoptera: Formicidae)

Many species

Size 3–12 mm

Biology and damage Ants do not cause any direct damage to olives, but disrupt biological control of black scale (p. 24). Ants enter the tree canopy searching for honeydew secreted by the scale and interfere with predators and parasites, thereby favouring the development of black scale infestations. In some cases, larger species of ants in foliage can be a source of annoyance for grove workers.

The movement of ants up a trunk is indicative of active black scale in the tree, even if the scales are not immediately obvious.

Natural enemies None significant.

Comments Baiting has been successful in other orchard crops.

Management of black scale will reduce ant problems, and vice-versa.

For further information see tutorial and flyer Black Scale (OliveBiz).

Ants attending scales

Armoured scales (Hemiptera: Diaspididae)

Red scale, *Aonidiella aurantii* (most common)
Oleander scale, *Aspidiotus nerii*
Ross's black scale, *Lindingaspis rossi*
Circular black scale, *Chrysomphalus aonidum*
Parlatoria scale, *Parlatoria oleae*

Size 2 mm

Biology and damage Armoured scales are most common in Queensland and WA, but have also been recorded in Hunter Valley NSW. There are two to six generations per year. First-generation crawlers normally emerge in late spring. Hot, dry weather reduces the survival of crawlers.

Scales infest leaves and twigs and, sometimes, fruit. No honeydew or associated ants (p. 21) or sooty mould (p. 61) occur. Infestations can cause fruit marking or pitting and scale-encrusted fruit. Leaf fall and twig dieback can occur in severe infestations.

Major natural enemies Small parasitic wasps, including *Aphytis melinus* and *A. lingnanensis*, both of which are mass-reared and commercially available, are commonly released into citrus orchards; wasps *Comperiella bifasciata* and *Encarsia* spp.; ladybirds, lacewings and predatory mites may occur naturally.

Comments Sprays need to be targeted at crawlers and young nymphal stages, so timing is critical for effective management. This makes monitoring for crawler development important.

Dust deposits on leaves deter natural enemies, so trees near farm tracks may have more severe problems.

Opening up tree canopies exposes crawlers to greater likelihood of dehydration, and also to access by sprays targeted against them.

Red scale infestation on leaves and fruit of 'Jumbo Kalamata'

Top **L** Red scale infestation on mid-vein of olive leaf

R Parlatoria scale on olive leaf

Bottom **L** Armoured scale parasite *Comperiella bifasciata* with red scale. Note wasp emergence hole

R Red scale parasite *Aphyis melinus* with red scale

Black scale, *Saissetia oleae* (Hemiptera: Coccidae)

Size 3–5 mm

Biology and damage Two or three generations occur per year. Widely distributed in Australia. First generation crawlers normally emerge in late spring.

Hot, dry weather reduces the survival of crawlers.

Scales attack leaves and twigs, resulting in leaf drop, reduced tree vigour and twig dieback in heavy infestations. Ants (p. 21) and sooty mould (p. 61) are commonly associated with the production of honeydew by adults and nymphs of black scale.

Major natural enemies Small parasitic wasps such as *Metaphycus* spp. and *Scutellista caerulea*; ladybirds (Coleoptera: Coccinellidae), lacewing larvae (Neuroptera) and the scale-eating caterpillar *Mataeomera dubia*.

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Heavy black scale infestation, showing associated sooty mould and ant attendance

Female black scales with emerging crawlers. Parasitoid, *Scutellista caerulea,* in bottom photo.

Top Adult female scale overturned, showing eggs

Bottom Scale-eating caterpillar (*Mataeomera dubia*) with black scale

Cicadas (Hemiptera: Cicadidae)

Various species, particularly bladder cicada,

Cytosoma schmeltzi

Size 30–40 mm

Biology and damage Cicadas have occasionally been recorded in central Queensland laying large numbers of eggs into olive twigs, causing severe damage. The females slit the twigs and insert rows of eggs. The emerging nymphs cause further damage before moving to the soil, where they feed on plant roots for several years. Adults emerge in spring to summer. There is no effective management strategy available, although incidence is rare.

Cicada oviposition damage to woody twig

Fruit flies (Diptera: Tephritidae)

Queensland fruit fly (QFF), *Bactrocera tryoni*, in NSW, Queensland and northern Victoria

Mediterranean fruit fly (medfly), *Ceratitis capitata*, in WA

Size Adults: QFF, 6–7 mm   Medfly, 4–5 mm

Biology and damage Female flies lay eggs in ripening fruit, causing small piercing marks. Larvae may develop in fruit. Damaged fruits may prematurely ripen or fall, and are predisposed to fungal fruit rots.

Natural enemies Braconid parasites (Hymenoptera: Braconidae), the assassin bug *Pristhesancus plagipennis* and birds, although these rarely achieve significant control. Other biological controls, including insect pathogens are being investigated. Area-wide management is encouraged against QFF in south-western NSW, and Victoria, including use of sterile insect technique (SIT).

Comments Commercial lures are available for both QFF and medfly monitoring. However, these target males and are not effective for direct control.

Protein baiting using yeast autolysate with a toxicant has been successfully used to target female fruit flies in other crops.

These fruit flies should not be confused with the closely related exotic olive fly. For further information on this biosecurity threat, see p. 67.

Top QFF adults

Middle Medfly adult

Bottom QFF larvae (maggots)

Grasshoppers (Orthoptera: Acrididae)

Plague locust, *Chortoicetes terminifera*

Spur-throated locust, *Austracris guttulosa*

Migratory locust, *Locusta migratoria*

Wingless grasshopper, *Phaulacridium vittatum*

Biology and damage Plague locust is the most devastating of the locusts, although wingless grasshopper can be a serious olive pest in southern and western Australia. In the non-swarming phase, grasshoppers feed primarily on terminal leaf margins, but the locust phase devours most green plant material, stripping trees rapidly.

Comments During plagues, immediate action is essential. Permits for pesticide use are normally issued in locust plague outbreak years.

Top Wingless grasshopper
Phaulacridium vittatum

Bottom Australian plague locust
Chortoicetes terminifera

Green vegetable bug, *Nezara viridula* (Hemiptera: Pentatomidae)

Size 15 mm

Biology and damage This large green stink bug damages fruit by piercing with its mouth parts, causing discoloured spots on the skin and flesh and contributing to fruit rots. Immature nymphs are commonly gregarious (found in groups), and are dark-coloured with lighter white, yellow and orange spots. This species has a wide host range, including field crops such as pulses and cotton, and may migrate from these crops to nearby olives.

Natural enemies A small egg parasite wasp, *Trissolcus basalis*, has been introduced and is well established in many districts.

Green vegetable bug adult and nymphal stages

Top Olives damaged by green vegetable bug

Bottom Green vegetable bug egg parasite *Trissolcus basalis* with vegetable bug eggs

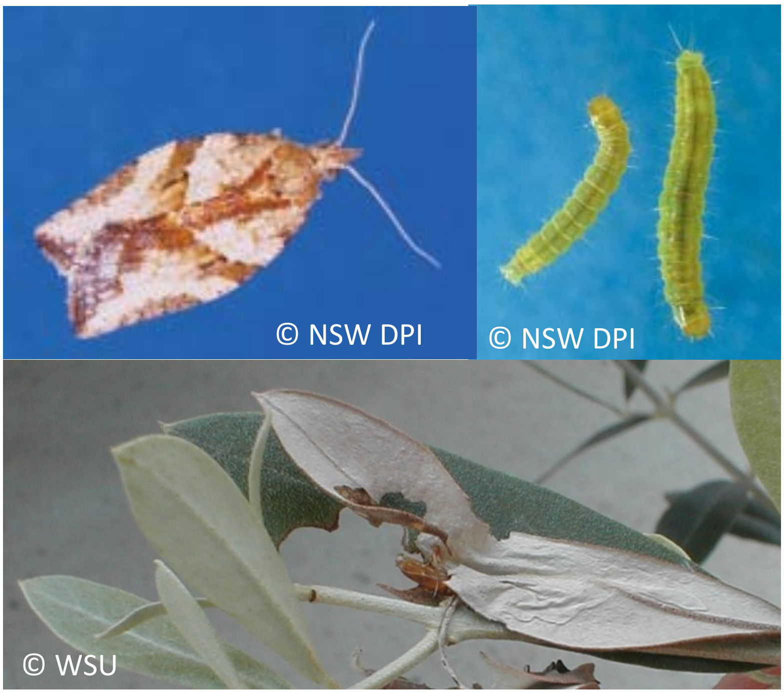
Lightbrown apple moth, *Epiphyas postvittana* (Lepidoptera: Tortricidae)

Size Adult wingspan 18 mm

Biology and damage Lightbrown apple moth (LBAM), *Epiphyas postvittana*, is a native species of leafroller with a wide plant host range. It occasionally damages growing tips or inflorescences of olives, tying them together with silken threads to form a protected area within which it feeds.

Natural enemies Various parasitic wasps, including the minute egg parasites *Trichogramma* spp. LBAM is susceptible to the bacterial pathogen *Bacillus thuringiensis*.

Comments *Trichogramma carverae* and *Bacillus thuringiensis* are commercially available.



Top **L** Adult light brown apple moth

R Larvae (caterpillars)

Bottom LBAM damage to leaves

Olive bud mite, *Oxycenus maxwelli* (Acari: Eriophyidae)

Size 0.1–0.2 mm

Biology and damage Bud mite was first detected in NSW in 2000, although is most commonly reported as a pest in WA. The mites feed on developing buds, shoots and leaves, causing malformations and shortening of internodes between young leaves ('witch's broom' effect). Most severe in young trees under conditions of warm temperature and high humidity.

Natural enemies Likely to be attacked by predatory mites (family Phytoseiidae) and small ladybirds (e.g. *Stethorus* spp.).

Olive bud mite damage, showing malformed growing tips

Top Olive bud mites on young leaf (magnification 40×)

Bottom *Euseius elinae* mite, predator of eriophyid mites

Olive lace bug, *Froggattia olivinia* (Hemiptera: Tingidae)

Size Adults 3 mm

Biology and damage An Australian native species recorded in NSW, ACT, Qld, Vic, SA, WA and most recently Tas. Adults are mottled brown. There are two to four generations per year. Spiny nymphs occur in clusters on undersides of leaves; the first generation commonly emerge from leaves in spring. All stages attack leaves with piercing mouthparts, causing yellow spotting. Black tar spots occur on undersides of leaves. Leaf drop and twig dieback may occur in severe infestations.

Natural enemies Few have been recorded; green lacewings have been observed predating on lace bug nymphs, and spiders on adults and birds may also be predators.

Comment The native green lacewing *Mallada signata* is commercially available (see Beneficial Species p. 17).

Further information see tutorial and flyer Olive Lace Bug (OliveBiz).

Adult olive lace bugs

L Male **R** Female

Top Life cycle of olive lace bug

Middle Mixed nymphal stages of olive lace bug

Bottom Adult olive lace bugs entering overwintering

Top Lace bug damage

Bottom L Larva of green lacewing *Mallada signata*, predator of olive lace bug nymphs

Bottom R Egg of green lacewing

Rutherglen bug, *Nysius vinitor* (Hemiptera: Lygaeidae)

Size Adult 5 mm

Biology and damage Commonly breeds on weeds, especially developing seeds. Occasionally reaches plague numbers in spring and summer and may swarm onto trees. Heavy feeding can cause severe damage with scorched appearance of leaves and death of twigs.

Generally of minor importance, although may be prevalent in some districts in favourable seasons.

Comments Closely related species with similar habits include grey cluster bug *Nysius clevelandensis*, coon bug *Oxycarenus arctatus*, and cottonseed bug *Oxycarenus luctuosus*.

Rutherglen bug adult (L) and nymph (R)

Snails (Mollusca: Gastropoda)

Snails, including the small brown snail *Microxeromagna vestita* and the white Italian snail *Theba pisana*, are a problem in some areas of SA and WA. They appear to cause limited feeding damage, but they rest in trees, smothering trunks and branches, and occasionally causing broken limbs from their weight. In SA they move off trees in autumn and are not present during the critical harvest period, when they could contaminate the fruit.

White snails on young olive tree

Thrips (Thysanoptera)

Plague thrips, *Thrips imaginis*

Western flower thrips, *Frankliniella occidentalis*

Size *T. imaginis* fem. 1.0–1.3 mm, male 0.8–1.0 mm

F. occidentalis fem. 1.4–1.8 mm, male 0.9–1.1 mm

Behaviour and damage Thrips are small, elongated insects with fringed wings. Adults range in colour from yellow to mid-brown. Larvae are white or cream and wingless. Both species have been recorded in olive flowers, but plague thrips is the more common in flowers and on sticky traps in groves. Thrips commonly feed on understorey weed flowers in the grove or in nearby fields, swarming between spring and autumn. Flower infestations have been implicated in scarred and misshapen fruit.

Natural enemies Predatory thrips and predatory mites (Acari: Phytoseiidae) may attack thrips larvae.

Comments Predatory mites (e.g. *Typhlodromips montdorensis*) and predatory bugs (e.g. *Orius tantillus*) are commercially available for use in greenhouse crops against *F. occidentalis* and other thrips species. Field use is unclear, particularly in absence of pollen sources.

Thrips feeding on flower stamens

Weevils (Coleoptera: Curculionidae)

Curculio beetle, apple weevil, *Otiorhynchus cribricollis*, in inland NSW, SA & WA (most common species)

Garden weevil, *Phlyctinus callosus*, mainly in WA

Size *Otiorhynchus cribricollis*, 9 mm

Phlyctinus callosus, 7 mm

Biology and damage Adults are nocturnal and flightless, emerge from the ground in summer and climb trees to chew leaf margins, creating a typical scalloped appearance. Severe infestations can damage growing tips, and reduce yield, especially in young trees. The soil-dwelling larvae (legless grubs with white bodies and brown heads) may feed on plant roots, but there are no reports of serious damage to olives.

Comments An effective alternative to insecticide application to butts of trees is the use of either a sticky or a fibrous barrier applied to the tree trunk. In the latter case, apple weevils in particular become enmeshed in the fibres.

Poultry, including guinea fowl, have been reported to contribute to garden weevil control in orchards and vineyards.

Check new plantings for leaf and stem feeding. Confirm whether these weevils are the cause by observations at night or digging around the base of trees during the day.

Trunk bands made from artificial fibre will entangle apple weevil adults but are less reliable in trapping garden weevil adults.

Sticky material such as polybutene will help exclude garden weevil adults from the tree canopy but not apple weevil. This material is phytotoxic to olive trees and needs to be placed on a substrate such as plastic.

Further information see tutorial and flyer Apple Weevil (OliveBiz).

Top L Apple weevil adult

Top R Apple weevil larva

Middle L Garden weevil adult

Middle R Apple weevil barrier applied to tree trunk

Bottom L Apple weevil damage showing scalloped leaf margins

Diseases

Anthracnose

Cause Fungus: *Colletotrichum acutatum*, *C. gloeosporioides* and *C. simmondsii*

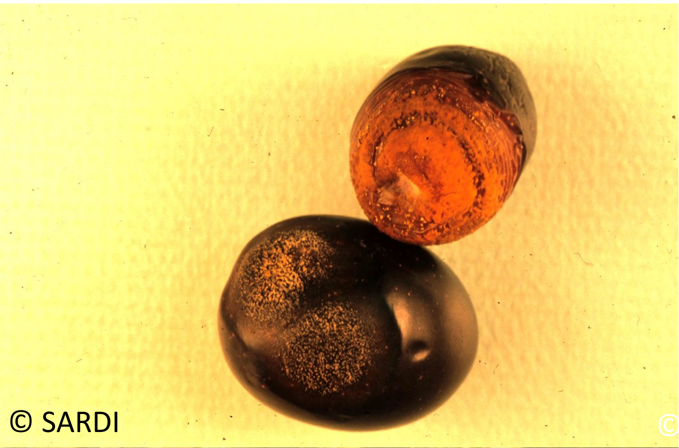
Symptoms Causes soft circular rots on the fruit, usually on the shoulder, and at high humidity produces an orange slimy mass of spores on the fruit surface (soapy fruit). Commonly seen close to harvest when fruit softens. Young shoots and leaves can also be infected causing dieback.

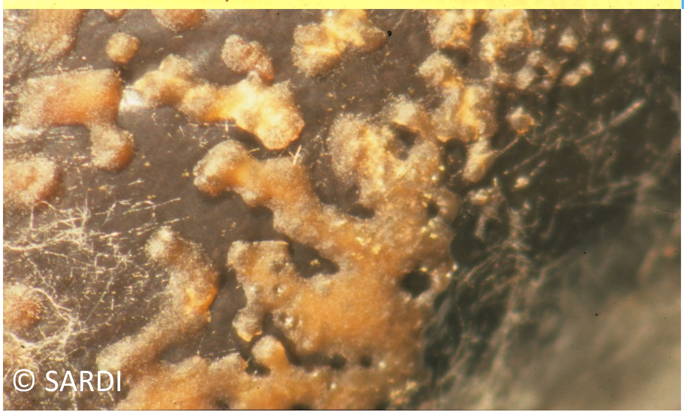
Transmission Survives on infected mummified fruit and infected twigs. Early season infections occur through flowers. Spores are spread by rain splash and wind. Infection can remain latent until fruit matures. Spores can infect ripe fruit and form new spores within 4 days.

Favoured by Wet conditions with high humidity.

Comments Spray programs need to commence in winter along with removal of previous seasons fruit and pruning to open up the tree canopy. Olive cultivars also vary widely in susceptibility.

Further information see tutorial and flyer Anthracnose (OliveBiz).





Top Orange to pink spore masses on infected fruit

Bottom Sporulating anthracnose lesions on fruit

Cercospora leaf mould

Cause Fungus: *Pseudocercospora* (= *Cercospora* = *Mycocentrospora*) *cladosporioides*

Alternative names Cercospora leaf spot, Cercosporiose

Symptoms Grey mouldy blotches develop on the underside of the leaves. The tops of the leaves turn yellow, then brown, and finally drop. Defoliation mainly occurs on the inner parts of the tree canopy. Significant leaf drop weakens trees to further pest and disease attack. Often occurs together with peacock spot, causing significant defoliation and damage to new growth and reduced crop production, delayed fruit ripening and decreased oil yield. Fruit are rarely infected, but, if so, show round, reddish-brown spots. Fruit from affected trees may also abort or drop prematurely.

Transmission In autumn leaf lesions enlarge, forming new spores. The fungus over-winters in old infected leaves. Winter rain and winds allow spores to disperse. There is a long latent period (up to 11 months) between infection and symptom development.

Favoured by High humidity and rain, 12-28°C. The optimum temperature for spore germination is 21-22°C.

Comments Olive varieties can vary in susceptibility. Fungal spores on fallen leaves are a potential source of new infections so mulching with organic matter may reduce carry-over of the pathogen between seasons.

Further information See tutorial and flyer Cercospora leaf mould (OliveBiz).

Top Grey mouldy blotches on underside of yellow to brown leaves
Bottom Mouldy appearance from fungal spores

Charcoal rot

Cause Fungus: *Macrophomina phaseolina* (AKA *Rhizoctonia bataticola*)

Symptoms Mostly affects young trees in dry soils. Plants die back from the shoots, and leaves drop. Infected roots appear grey and are dotted with tiny (pinhead-sized) black sclerotia, which are survival structures of the fungus. Severely affected roots blacken and rot away.

Transmission Soilborne. This fungus survives in soil for many years and can infect roots and stems of a wide range of plants. It spreads in irrigation water and infected soil on farm machinery.

Favoured by Warm and dry soils. Leaf symptoms develop when plants are heat stressed.

Crown gall

Cause Bacterium: *Agrobacterium tumefaciens*

Symptoms Forms swellings and galls on stems and roots near soil level. Galls start as small, pale lumps of tissue, which enlarge, darken and become convoluted. Galls can vary considerably in size. Can be confused with olive knot galls (p 50). Trees may become unthrifty.

Transmission The bacteria live in soil and infect plants through wounds. Infected cells receive a cancerous factor from the bacteria, which causes them to divide uncontrollably and thus form the galls. The bacteria infect a wide range of plants, particularly woody perennials.

Favoured by Continued in-ground planting of susceptible hosts. More prevalent on young nursery stock. Wounding by grafting, budding, cultivation etc. provides entry points for the bacteria.

L Galling at soil level on potted olive tree

R Galling on main branch of olive seedling

Nematodes (Eelworms)

Root knot nematode, *Meloidogyne* spp.

Citrus nematode, *Tylenchulus semipenetrans*

Root lesion nematode, *Pratylenchus* spp.

Symptoms Vary from unthriftiness to stunting and leaf yellowing. Root knot nematodes cause distinctive root galling.

Transmission Soilborne microscopic roundworms, spread with movement of soil, water and infected plants.

Favoured by Soil that previously grew host plants. For example, citrus and root lesion nematodes are common in old citrus land, and root knot nematode is common in old vegetable soil. Damage would be expected to occur with high populations.

Root knot nematode damage, showing root galls

Olive knot

Cause Bacterium: *Pseudomonas savastanoi* pv. *savastanoi* (Pss).

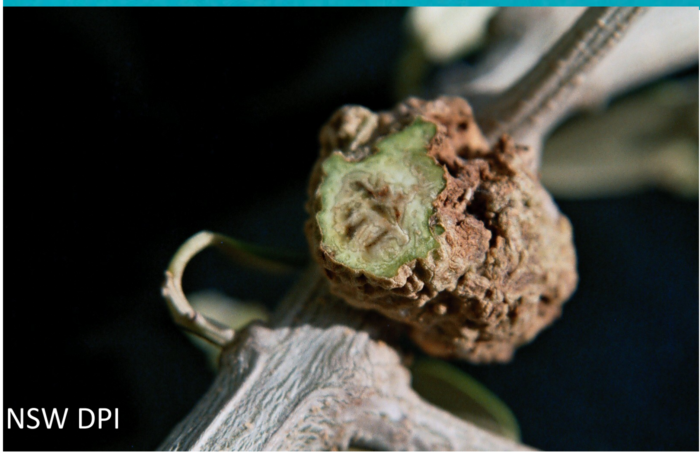
Symptoms Rough galls or swellings of variable size occur on twigs, branches, trunks, roots, fruit or leaves. Galls can appear either singly or close together. They are most common on twigs and young branches, but will also form around wounds on the main trunk. Starting as small swellings 3 to 5 mm across, they grow rapidly into smooth, spherical green knots, increasing in size as they mature and becoming darker and more furrowed.

Transmission The bacteria live in the galls and ooze out in wet weather. They enter the tree through wounds, including leaf scars, damage by hail and frost, pruning wounds or wounds caused during harvesting.

Favoured by Trees at most risk are those with wounds during periods of rain. Some cultivars are more susceptible, e.g. Barnea and Frantoio.

Comment Pss can form a stable community inside galls with other bacteria such as *Erwinia toletana* which results in more aggressive disease symptoms, such as bigger galls.

Note Olive knot has not been detected in all states. If you see symptoms, notify your state department of agriculture.



Top Galling around wound site

Bottom Bacteria inside olive knot

Peacock spot

Cause Fungus: *Venturia oleaginea* (AKA *Spilocaea oleaginea*, *S. oleagina* and *Fusicladium oleagineum*)

Alternative names Olive leaf spot, bird's-eye spot, olive scab

Symptoms Most new infections occur on young spring growth during wet weather, which is followed by a latent period of about 30 days. Round spots form on the upper surface of the leaf (2 to 10 mm in diameter), and occasionally brown sunken lesions develop on stems, peduncles and fruit. Spots first appear as small pale blotches, later becoming muddy green to black, often with a yellow halo. Under higher temperatures older lesions develop into whitish scabs, where the cuticle separates from the epidermis.

Severe infection may cause defoliation, which can kill new wood and reduce production in the following year.

Transmission Fungus overwinters in old infected leaves. Spores germinate in free water and are blown or splashed onto the leaves. Spores attached to leaf trichomes can also be dispersed by wind. Movement between trees is limited, although adult Psocoptera insects (booklice or psocids) are also thought to move spores longer distances.

Favoured by High humidity and rain. Usually occurs sporadically, particularly during wet weather in spring. Optimal temperatures for infection are between 15-20°C and greater than 12 hours of leaf wetness. Young leaves are more susceptible. Olive varieties vary in susceptibility. Disease is generally inactive during summer.

Comments Management of this disease has traditionally relied on cultural practices such as mulching or removal of fallen leaves over winter, together with pruning to open up the canopy, and fungicide applications.

Further information see tutorial and flyer Peacock Spot (OliveBiz).

Top Spots on upper surface of leaves, one with yellow halo

Middle Early infection on leaves

Bottom Spots on fruit

Phytophthora root rot

Cause Water mould: *Phytophthora* spp. (several species)

Symptoms Root and crown cankers that may extend up the trunk. Leaves wilt, yellow and may drop. Trees may die suddenly, or slowly decline over several years. Sudden death is common when trees are stressed, such as during flowering, fruit development or hot weather.

Transmission Soilborne organism, spread by movement of soil, water and infected plants.

Favoured by Phytophthora root rot is consistently associated with excessively wet soils, clay-panning (p. 60) or poor drainage. Care must be taken when using feral plants as rootstocks, as many grow in areas where *Phytophthora* is present in the soil.

L Crown canker on 5-y-o tree

R Severe rotting of roots and lower stem

Rhizoctonia root rot

Cause Fungus: *Rhizoctonia* spp.

Symptoms Roots turn brown, and their outer layer of tissue may slough off. Black sclerotia (survival structures) may form on roots. Above-ground symptoms are similar to water deficit effects, and include leaf tip death, defoliation and plant death.

Transmission Soilborne fungus, spread by movement of soil and infected plants.

Susceptibility Young nursery plants or new transplants are most affected. Healthy mature trees can be infected but are largely unaffected.

Several species of *Rhizoctonia* have been detected in olive roots, but it has not yet been determined whether all these species cause disease.

L Browning of roots on olive seedling

R *Rhizoctonia* sclerotia on roots

Verticillium wilt

Cause Fungus: *Verticillium dahliae*. There are different strains of this fungus that can infect olives; often referred to as “defoliating” or “non-defoliating” strains. Endemic strains are poorly characterized in Australian olives; however the cotton defoliating strain is still considered a biosecurity threat in Australia (see Key olive pests & diseases not detected in Australia section in this Guide p.73).

Symptoms One or more branches wilt, usually early in the growing season. Dead leaves remain on the tree. Roots are repeatedly infected over several seasons and trees gradually die. Internal tissue of lower stems may darken as the fungus disrupts the ring of sap-carrying tissue under the surface. Olive cultivars vary greatly in susceptibility, and symptoms may not be seen for 4 to 8 years after planting. Depending on the strain of the fungus symptoms may develop rapidly in late winter and early spring or may progress as a slow decline through this period.

Transmission Soilborne. The fungus survives in soil for many years and can infect the roots of a wide range of plants. It can spread in irrigation water and infected soil on farm machinery and tools.

Favoured by Cool and moist soils when daytime temperatures range between 20 and 25°C. Suppressed by higher temperatures. Common in land where alternate hosts (e.g. cotton, lucerne, brassicas, *Prunus* species) have been grown.

Mature tree with wilted branch

Top Young tree with wilted branch

Bottom Darkened ring of water-conducting tissue inside stem

Wound cankers

Cause Opportunistic wound invaders

Fungi: e.g. *Botryosphaeria* sp., *Pycnoporus coccineus* (white wood rot)

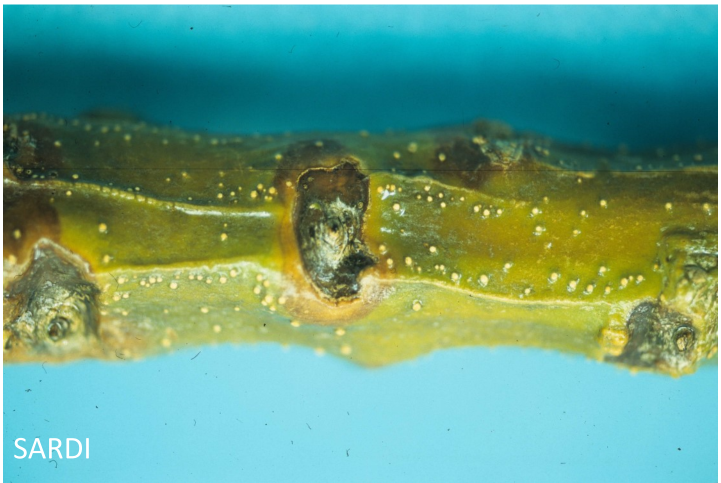
Bacteria: e.g. *Pseudomonas syringae*, *Ralstonia solanacearum*, *Xanthomonas campestris*

Note that in overseas olive production there are a number of fungi described that cause similar symptoms to those species described below. These include species of the fungi *Neofabraea*, *Neofusicoccum*, *Cytospora* and *Diplodia*. Similar fungi are known to occur on other woody tree crops in Australia but have not been studied on olives. Some of these fungi can also cause fruit rots.

Symptoms Vary from slow decline of trees and tree death to localised cankers around wound sites with occasional branch death above infection. Can also cause brown staining of the vascular (sap-carrying) system.

Transmission All are wound pathogens. Can be borne by wind, water and soil. Most are common organisms that opportunistically infect through wounds.

Favoured by Wounds, wetness and high humidity causing moisture films around wound sites.



Top L *Pseudomonas syringae* causing localised wounds at leaf scars

Top R Entry of bacteria at pruning wound caused stem death

Bottom Brown internal staining from *Ralstonia* infection

Disorders

Apical end rot

Alternative names Apical end desiccation, soft nose

Symptoms The apical (blossom) end of the fruit shrivels, mostly close to maturity. The internal flesh and pip may be blackened, either at the apical end only or throughout the whole fruit. Sometimes secondary fungal rots infect the shrivelled end.

Cause The cause is not fully understood. It may result from sudden changes in temperature and humidity, which produce partial dehydration of the fruit at the apical end. It has also been associated with calcium and boron deficiencies, and with changes in watering regimes.

Apical end rot can lead to secondary fungal rots.

Top Apical end rot in the field

Bottom L Fruit showing typical apical end rot symptoms

Bottom R Rot can be internal at apical end only or throughout the whole fruit

Clay-panning & root plaiting

Clay-panning and root plaiting are disorders in root architecture that can lead to unthrifty plants that are subject to stress-related dieback and infections.

Clay-panning is caused by poor soil structure and ground preparation, whereby a hard layer of subsurface soil prevents roots from growing downwards. Affected trees may also be subject to temporary waterlogging, which can lead to further disorders and infections.

Conversely, dry soil can exacerbate stresses, because plants cannot draw moisture from deeper in the soil. Trees may also be subject to blowing over in strong winds because of their poorly anchored root systems.

Root plaiting occurs when plants become pot-bound during their nursery production. Plants have reduced and weaker root systems, which allow environmental stresses to lead to various disorders and infections.

Sooty mould

Cause Fungi: *Capnodium* spp. (most common); also *Fumago*, *Scorias* and *Aureobasidium* spp.

The fungi are wind-blown and attach to and grow on the honeydew excretions from sap-sucking insects, particularly black scale (p. 24), but also aphids, mealybugs and psyllids.

Symptoms A black soot-like growth which can cover all surfaces of the plant. Severe infections can indirectly cause plant stunting and unthriftiness, as the soot coverage prevents sunlight penetration and thus photosynthesis by the plant.

Control To manage sooty mould, the insects producing the honeydew must be controlled. For olives, the most common cause is black scale (p. 24).

Sooty mould associated with black scale infestation

Sphaeroblasts and oedema

Sphaeroblasts are knob-like growths up to 10 mm wide which protrude from stems. When they are cut open, a spherical lump of wood can be removed from the surrounding tissue. Their cause is unknown, and they commonly occur on cv. Barnea.

Symptoms of **oedema** are small, brown, corky growths up to 5 mm wide that form on the surface of stems or roots from enlarged lenticels (breathing holes in bark). They occur when high soil moisture causes excessive water uptake, which engorges the cells near the lenticels. These cells can rupture from the high water pressure, and the plant forms callus tissue in an effort to heal. When roots experience periods of high soil moisture, some tissue may also asphyxiate (because of reduced oxygen levels). Consequently, these roots are predisposed to infection by a range of minor pathogens or opportunistic invaders such as *Fusarium*, *Pythium* and various bacteria.

L Spaeroblasts on cv Barnea

R Oedema

Stem death

Symptoms The stem of the plant dies a few centimetres above ground level. The base is generally healthy and new shoots will often appear below the dead stem. Most common on young trees in their first and second years in the field.

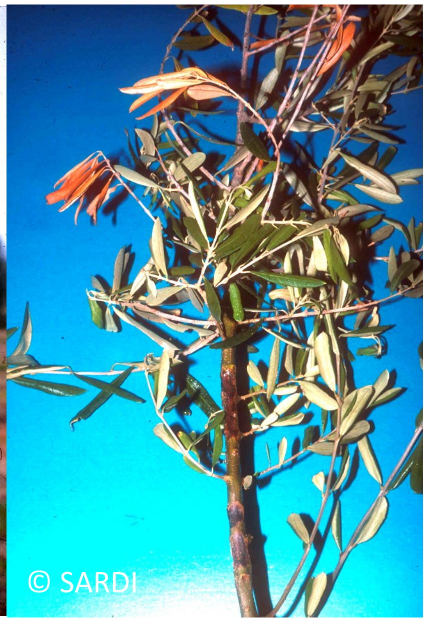
Cause Unknown. Damage occurs to the young tree and allows entry of wound-invading bacteria and fungi (see Wound Cankers, p. 57). Damage is often associated with cold temperatures, sun scald and herbicides, but in many cases the cause has not been determined.

Examples of stem death. Note on LHS specimen, there is healthy tissue below

Tip death

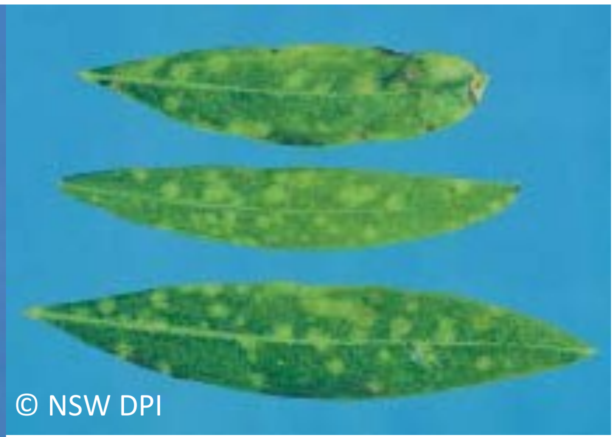
Symptoms Ends of branches die for no apparent reason. Tip death appears to have no effect on the general health of the tree or its productivity. Branches can be removed if this is considered necessary for cosmetic purposes.

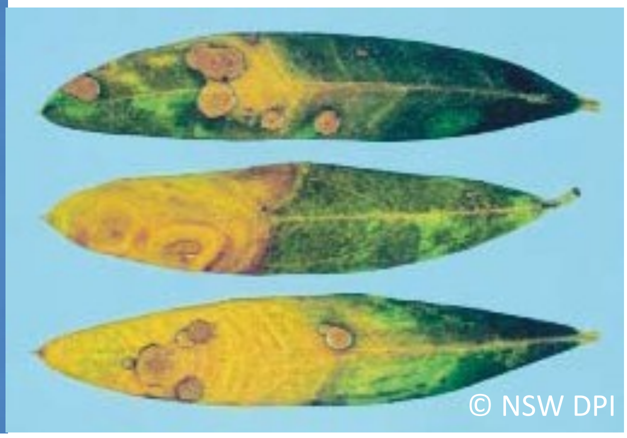
Inspection of the stem below the dead tips is needed to determine whether the death has a specific cause which should be further investigated (see Wound Cankers, p. 57). Root rot and trunk cankers can also cause tip death, and so should be investigated.



Miscellaneous leaf damage

There are many other symptoms seen on leaves that have no known cause. They may result from infection by biotic agents or from environmental or nutritional effects. Symptoms include white spotting, pale brown blotches, striping and yellowing, and dead tips.





Key olive pests & diseases not detected in Australia

There are many pests and diseases both of olives and other crops overseas that are potential threats to the olive industry. The Biosecurity Plan for the Olive Industry (Version 2.0 – 2016) lists five High Priority pests, based on the criteria of Entry potential, Establishment potential, Spread potential and Economic impact. These pests are listed as:

- Olive fly (*Bactrocera oleae*)
- Olive moth (*Prays oleae*)
- Leaf scorch (*Xylella fastidiosa* subsp. *multiplex* (with vectors))
- Olive quick decline (*Xylella fastidiosa* subsp. *pauca* (with vectors))
- Verticillium wilt (*Verticillium dahliae* (exotic defoliating strains))

For the listed pathogens, there is confused taxonomy. As a result, *Xyllella* is treated singly in this section. For further information on these exotic pests and other aspects of biosecurity, see Tutorial 3 (OliveBiz).

The following provides information on biology, description and damage associated with the High Priority Olive Pests and Diseases.

If you suspect you've found a new pest or disease, immediately call the Exotic Plant Pest Hotline on 1800 084 881.

Olive fly, *Bactrocera oleae* (Diptera: Tephritidae)

Size 5 mm long

Biology and damage Olive fly is the most important and destructive pest of olives worldwide. It is widely distributed in the Mediterranean basin, northern and southern Africa, and Western Asia, including India, Pakistan. Since the late 1990s, it is also present in California (arrived from Mexico).

The female lays eggs in fruit, often when it is green, and developing larvae (maggots) feed on the olives, usually causing fruit drop. Mature larvae normally pupate in the fruit or leave them and pupate in the soil, where they overwinter. Fruit rot and lower oil quality are associated with damage. In the USA, olive fruit is required to be <1% infested for processing. If uncontrolled, olive fly can result in 100% loss of the table olive crop and 80% loss of the oil crop. It appears that olive fly has a preference for some cultivars, particularly large-fruited ones.

Olive fly is related to, and looks similar to, the native Queensland fruit fly (p. 28), but is slightly smaller, has dark marks on its wing tips and has slightly different body markings.

Furthermore, unlike Queensland fruit fly and Mediterranean fruit fly, it attacks green fruit and normally pupates in fruit. It is attracted to a specific pheromone (communication chemical) that is different from those of both QFF and medfly, which is used to monitor it and as part of a control strategy.

Control is difficult and costly.

Further information see Tutorial 3 Biosecurity (OliveBiz).

Top Female olive fly (note black wing tips, not present in Queensland fruit fly)

Middle Green olive fruit showing oviposition "sting" marks

Bottom 2nd instar larva (maggot) tunnelling into fruit

Olive moth, *Prays oleae* (Lepidoptera: Yponomeutidae) **Alternative name Olive kernel borer**

Size Adult moth 6 mm long, 13 mm wingspan

Biology and damage Olive moth is widespread in Mediterranean countries including northern Africa, and other European locations, including UK. The only host is olive and closely related Oleaceae. Adult moths are silvery grey, and have long antennae. Larvae can grow to a maximum length of 8 mm. Their colour varies, but mainly light brown and green. The pupal stage, is protected by loose silk webbing.

There are normally 3 generations per season. The first generation arises from eggs laid by overwintered adults on flower buds and flowers. Emerging caterpillar feed on pollen, anthers and female parts of flowers. Frass (faecal pellets and webbing) may be present. Caterpillars of the second generation are the most harmful, burrowing into fruit and feeding near the kernel, causing severe fruit damage and fruit drop. Those of the third generation feed on leaves, including leaf mining and shoot bud damage. Reported crop losses are variable.

Control is achieved most commonly by pesticides. Pest presence (but not population size) is monitored by using a synthetic pheromone (sex attractant for male moths). https://www.praysoleae.eu/, or light or food traps. Pheromones are also being evaluated to manage olive moth by disrupting mating, although not yet commercially available. Although effective, optimal management requires area-wide treatment.

Further information see Tutorial 3 Biosecurity (OliveBiz).

Adult olive moth

Top 1st generation larva feeding on flowers (note webbing)

Second from top 2nd generation caterpillars feed on developing fruit

Third from top and bottom 3rd generation caterpillars feed on and mine leaves

Xylella, Olive quick decline, Leaf scorch, *Xylella fastidiosa*

Xylella fastidiosa is a bacterial pathogen that infects over 360 different plant species, including olives. There are several strains (subspecies) of this bacterium; some are limited to certain plant hosts.

At least two strains affect olives and are considered a biosecurity risk as they have not been detected in Australia. They are: *X. fastidiosa* subsp. *pauca* and *X. fastidiosa* subsp. *multiplex.*

The bacteria live in the plant xylem (water-conducting) vessels, inhibiting the uptake of water and nutrients which leads to disease symptoms that look like water stress – called leaf scorch. A particular strain of *X. fastidiosa* subsp. *pauca* – called Olive Quick Decline Syndrome (OQDS) – causes dieback, and death of trees.

OQDS was first reported in olives in southern Italy in 2013, but has since been reported more widely, including in Brazil.

Most introductions of *X. fastidiosa* occur with the movement of infected plant material. Once present, xylem-feeding insect vectors including leafhoppers and spittlebugs are the primary pathway by which it is spread through a country or region. Hence, known exotic vectors of Xylella are included in the listed biosecurity threat.

There is currently no known cure or treatment for *X. fastidiosa* infections. Some olive varieties e.g. Leccino and Favolosa FS-17 appear to be more tolerant while Kalamata, Coratina and Cellina are the worst affected.

Top Leaf scorch

Middle and bottom Abandoned OQDS-infected groves in Puglia, Italy

Verticillium Wilt (defoliating strain) *Verticillium dahliae*

Verticillium dahliae is a soil-borne fungal pathogen that infects roots and travels up the xylem into the trunk and lower branches causing them to wilt. Verticillium wilt is described earlier in this Guide (p. 55)

One strain of this fungus has been distinguished as the 'defoliating strain' (DS) on cotton in the USA. It causes wilt and death of olive trees in California and parts of Europe. DS has not been recorded in Australia on olives and is considered a biosecurity threat.

Leaves in infected trees can drop when green or turn brown, often with a downward rolling along leaf margins – symptoms appear from autumn to late spring. Only some limbs or branches of a tree may be affected, giving the tree a patchy or one-sided appearance. The surface of affected branches may have dark markings or be symptomless. Trees (particularly younger ones) often die or linger with reduced vigour.

Tree showing symptoms from Verticillium wilt (defoliating strain)

Devastated olive grove from Verticillium wilt (defoliating strain), California

Glossary

Abiotic—Caused by non-living factors.

Beneficial organism—An organism that helps the crop.

Biological control—The use of living organisms to control pests or diseases.

Canker—Dead or diseased area on a branch or stem.

Chlorotic—Pale yellow.

Crawler—The juvenile stage of scale insects.

Defoliation—Loss of all leaves from a branch or tree.

Disease—Any adverse effect on plant growth and development. In this guide we have used ‘disease’ to describe damage caused only by pathogens.

Disorder—Any adverse effect on plant growth and development from an abiotic cause.

Gall—An abnormal growth of plant tissue from proliferation of cell division, similar to callus tissue.

Honeydew—A sugary solution excreted by many sap-sucking insects.

Integrated pest and disease management—The combination of several strategies to control pests and diseases for maximum results with minimum drawbacks.

Larva—The juvenile stage of an insect; commonly used for caterpillars and grubs.

Lenticels—Natural pores or breathing holes in the outer layer of plant tissue.

Nymph—The juvenile stage of an insect in which the juvenile and adult look very similar.

Opportunistic—Making use of an opportunity that presents itself, rather than looking for a goal. Often used to describe an organism that infects plant material through wounds or damage inflicted by another cause, either abiotic or biotic.

Oviposition—The laying (positioning) of an egg (ovum).

Parasite—An organism that derives its nourishment from another organism without killing it.

Parasitoid—An organism that derives its nourishment from another organism and eventually kills it.

Pathogen—Any organism that causes disease, e.g. bacterium, fungus, virus.

Predator—An organism that catches others for food.

Pupa—The case-like intermediate stage of many insects between larva and adult, in which the insect develops.

Sclerotia—Small, black resting bodies of a fungus which enable it to survive without the plant host.

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