FIELD GUIDE

Pests, Beneficials, Diseases and Disorders of Mangoes

Queensland Government

Northern Territory Government

Department of Agriculture and Food Government of Western Australia

amia Australian Mango Industry Association Ltd

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FIELD GUIDE
to Pests, Beneficials, Diseases and Disorders of Mangoes

December 2010

Northern Territory Government
Department of Resources
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Foreword

In the last few decades, pest and disease management has taken a distinctly ecological approach. Integrated Pest Management (IPM) has been developed as an effective and environmentally sensitive approach to pest management that relies on a combination of common-sense practices. IPM programs use current, comprehensive information on the life cycles of pests and their interaction with the environment. This information, in combination with available pest control methods such as chemical, biological, host-plant resistance and cultural practices, are used to manage pest damage by the most economical means, and with the least possible hazard to people, property, and the environment. Most recently, management of pests or diseases at a District, rather than a farm level, known as Area Wide Management, has emerged as an important extension of IPM. Our Department fully embraces the principles of IPM, of which this mango field guide is an essential tool.

This guide is the second edition of the very popular guide first published by the Department in 2002. This new edition has been completely re-written and gives comprehensive information on mango pests, diseases and disorders, as well as beneficial organisms (natural enemies of the pests) in Northern Australia. Its clear illustrations and photographs allow accurate identification in the field by most IPM practitioners, whether they are growers, in-field agronomists, extension officers or research scientists. It has been compiled by entomologists, plant pathologists and horticulturists with many decades of combined experience in the semi-arid tropics where mangoes are most commonly grown.

What is also important about this guide is that pollinators are described and illustrated. This area, often neglected and poorly understood, will become more and more relevant as the industry, partnering with Government, strives to increase production efficiency and yields.

As with all publications of this type, further revisions will be necessary as new species are identified or discovered, or new information comes to light from the collective efforts of researchers, growers and associated support industries. At the moment, however, it represents the best information available, and I commend it to you for your frequent use and congratulate its authors on their efforts in its production.

Bob Williams

Director, Plant Industries Group
Northern Territory Government
Department of Resources
December 2010

Introduction

This illustrated Field Guide gives an introduction to the identification of some common pests, beneficials, diseases and disorders of mangoes in northern Australia (Northern Territory, northern Queensland and northern Western Australia). It also includes a description of several beneficial insects and spiders, as well as some nutritional and physiological conditions that may be confused with pest or disease symptoms.

The information in the Field Guide is the best available at the time of publication and includes some life cycle development times which have been approximated for NT conditions (these will vary according to climatic conditions, human influences and environmental factors). Many other insects or mites may be found on mango trees and/or on mango fruit, including some that are of minor (or infrequent) economic importance as well as non-economic species. Growers are encouraged to be on the lookout for any new or unusual occurrences and to discuss these and any other concerns with departmental staff.

How to Use This Field Guide

This publication is divided into four main sections: insect pests, natural enemies, diseases and disorders. A monitoring bar grid has been provided to show which months the orchard should be monitored for a particular pest, disease or disorder. Some insects or mites may occur during the wet season months of December to February but monitoring is not usually essential during that period as trees are not flushing or producing flowers.

The crucial time for insect monitoring is during the period of flushing, flowering and fruit production, which includes the period from March to November.

A glossary at the back of this book has been provided for definitions of scientific terms.

Further Information

As this field guide is in pocket notebook format, the information it contains has been reduced from its original larger format. More detailed information is available on factsheets or agnotes from the Department's website. Telephone enquiries for the Northern Territory can be directed to the field areas listed on the next page.

Telephone enquiries

Entomology (Insects) insectinfo.dor@nt.gov.au	08 8999 2259
Plant Pathology (Diseases)	08 8999 2265
Horticulture horticulture@nt.gov.au (Disorders and cultivation advice)	08 8999 2357
Pesticides Regulatory Issues chemicalservices.dor@nt.gov.au	08 8999 2344
Plant Market Access Advice quarantine@nt.gov.au	08 8999 2118

Monitoring and IPM

Growers are encouraged to use this Guide to recognise the main pests and their natural enemies, diseases and disorders when monitoring orchards. Regular monitoring of trees throughout the year will give a good indication of the range of pests and their natural enemies in the orchard. Information obtained from monitoring is useful for predicting trends, the level of infestations and the extent of damage over the seasons.

Limit the spread of pests and diseases

It is good practice to reduce the movement of plant material between properties in order to prevent the potential spread of plant pests and diseases. If you know that you have a pest or disease DO NOT transport infested plant material to un-infested properties. Movement of plant material infested with pests and diseases such as mango fruit borer, mango seed weevil, fruit flies and mango malformation disorder may require treatment or should not be transported to un-infested areas. If you need advice on the movement of infested plant material, please contact 'Plant Market Access Advice' at the details shown above.

Treatments

A list of recommended chemicals was supplied in the 1st edition, however, pesticide registrations are constantly being updated by APVMA*, therefore if you need advice on pesticide recommendations please contact the appropriate department in your state or territory. Growers should read all labels before using chemicals and only apply the product according to the manufacturers' recommendations.

*APVMA = Australian Pesticides and Veterinary Medicines Authority

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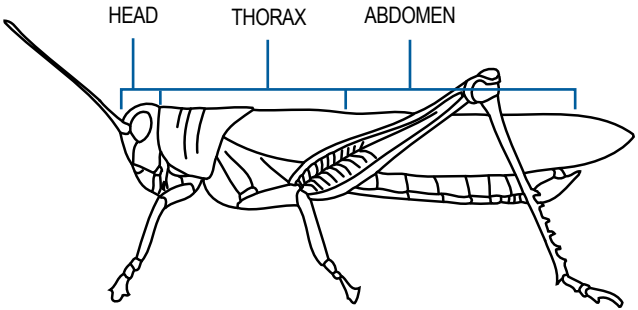
Biology and Life Cycles

Class Insecta

Basic body structure

- **Exoskeleton divided into 3 parts (head, thorax and abdomen)**
- **Three pairs of legs**
- **Usually 2 pairs of wings in adults**
- **One pair of multi-segmented antennae**

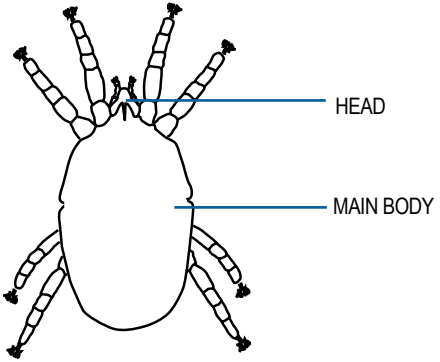
INSECTS



Class Arachnida

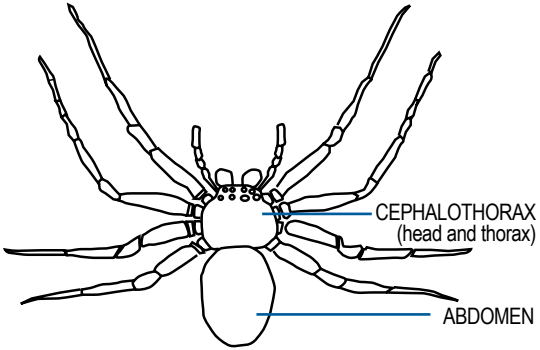
MITES

➔ **4 pairs of legs** **(immature mites have 3 pairs)**



SPIDERS

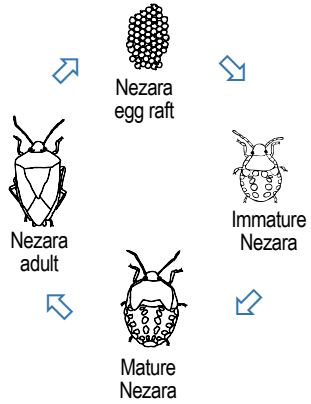
➔ **4 pairs of legs attached to the cephalothorax**



Incomplete metamorphosis

Incomplete metamorphosis is found in grasshoppers, cockroaches, mayflies, dragonflies, termites, and true bugs. The very young nymphs have no wings but as they moult they develop wing buds.

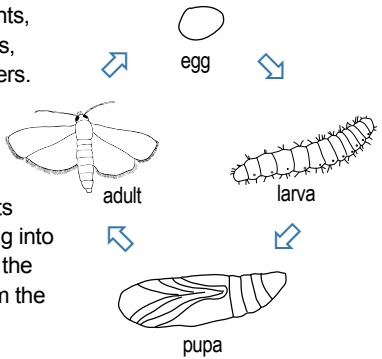
At each moult the wing buds get longer until the adult emerges after the last moult with fully developed wings.



Complete metamorphosis

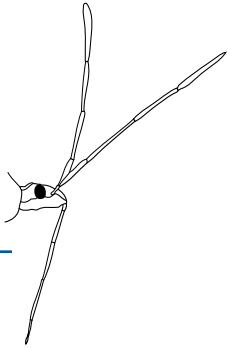
Complete metamorphosis is found in wasps, bees, ants, flies, beetles, cicadas, fleas, butterflies, moths, and others. Eggs hatch into larvae (e.g. caterpillars, maggots or grubs).

The larva grows and moults several times before turning into a pupa. In the pupal stage the body is restructured to form the emergent winged adult.



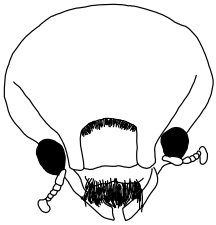
Types of feeding

Insect mouthparts vary according to what they feed on



Piercing needle-like mouthparts
for piercing and sucking plant sap.

e.g. Aphids, sucking bugs, mealybugs

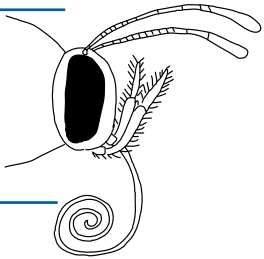


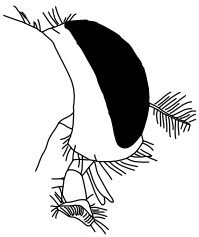
Chewing mouthparts
for chewing plant material or boring into wood.

e.g. Beetles, caterpillars, grasshoppers and termites

Sucking tubes
for extracting nectar from plant parts such as flowers.

e.g. Butterflies, moths





Sponge-like mouthparts
for lapping up and absorbing liquid.

e.g. Flies, bees

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Pests

Longicorn beetle

Acalolepta mixtus (Family Cerambycidae)

Description:

Eggs: Ovoid, white or light cream in colour.

Immatures: Larvae are white or light cream with a brown head, and constrictions along the length of the body. Size: up to 40 mm in length.

Adults: Dark grey or brown with a mottled back and antennae which may be at least as long as the body. Size: 20–30 mm in length.

Life Cycle: One generation per year. Eggs are laid into cracks and crevices in branches or trunks that have been damaged. Larvae feed and tunnel under the bark or into the wood. Adults emerge from the trees after pupating in the tunnels.

Similar to: The damage is similar to that caused by auger beetles which produces smaller tunnels and finer sawdust.

Damage: Recently pruned or stressed trees are more vulnerable to attack by longicorns. Affected trees have sap exudate on damaged areas and the bark may appear loose or lifted. Often damage is not noticed until the emergence holes of the adults are seen. Eventually the affected branches die.

Critical Control Period: Late wet season and early dry season.

Monitoring: Inspect trees for symptoms of stress or damage. Look for loose bark with lots of coarse sawdust underneath, for circular cut outs of bark with emergence holes underneath and holes packed with timber fibres. Symptoms are usually more obvious when they are advanced, especially during the dry season.

J	F	M	A	M	J	J	A	S	O	N	D

Above (L): Larva **Above (R):** Adult and emergence hole in branch
Below: Emergence hole with circular bark cut out

Mango seed weevil

Sternochetus mangiferae (Family Curculionidae)

Description:

Eggs: Creamy white in colour and elongate.

Immatures: White legless larva with a brown head.

Adults: Dark brown to grey-black oval shaped weevil with a prominent snout. Mottled markings on wing covers. Adults size: 10 mm in length.

Life Cycle: Eggs are laid onto fruit that are about 30 mm in length (or sometimes larger). After the egg is laid the weevil makes a small incision in the fruit skin which the sap flows out and covers the egg glueing it to the surface of the fruit. After the larvae hatch they tunnel through the fruit flesh moving directly to the seed, this takes about 1–2 days. Larvae feed inside the seed until they pupate. The emergent adult chews through the hard seed coating within 2 months of fruit fall. Development from egg to adult takes approximately 53 days. There is only one generation per year.

Similar to: Other native weevils.

Damage: At egg laying, fruit may be covered in many spots of oozing sap. By the time fruit is harvested the egg laying scars and tunnels in the fruit flesh are not noticeable. The only damage is to the seed.

Control Strategies: Mango seed weevil is a quarantine pest and fruit from infested properties should not be transported to uninfested areas. Removing fallen fruit reduces populations in infested areas. Pre-flowering and post-fruit set treatments of insecticide is recommended for control.

Monitoring: Adults may occasionally be seen moving onto branches and the outer canopy at flowering. Inspect young fruit for egg laying symptoms. Take random samples of fully developed fruit, and cut fruit to inspect the seed for larvae or pupae.

J	F	M	A	M	J	J	A	S	O	N	D

Above: Damaged seed with pupa and adult in seed
Inset: Egg laid onto surface of fruit
Below: Exuding sap covering egg laying sites

Red shouldered leaf beetle

Monolepta australis (Family Chrysomelidae)

Description:

Eggs: Unknown (not normally seen).

Immatures: White/cream in colour and up to 12 mm in length (not normally seen).

Adults: Yellow with a red spot on the base of each wing cover and a red mark across the top of the shoulders. Size: 4–8 mm in length.

Life Cycle: Eggs are laid into the soil. Larvae hatch in about 12 days and feed on the roots of grasses. They take about 3 months to mature. Larvae pupate in the soil, adult emergence takes place after the first rains at the onset of the wet season. There are usually two or three generations per year.

Similar to: A range of solitary beetles.

Damage: Leaves, flowers and fruit of native trees and horticultural tree crops may be affected. Large swarms of this beetle can cause defoliation leaving behind a vein network (skeletonising) which dries out or turns brown. They can also strip the bark from small branches which causes loss of vigour, poor fruit set and reduced fruit quality.

Critical Control period: Late wet season to flowering.

Other comments: Large swarms can develop between December and April. When conditions are optimal small numbers of beetles can survive throughout the dry season by sheltering under the leaves and bark of trees, especially in humid areas. Swarms generally occur in one or two trees on the outer edge of the orchard and within several hours or a few days may increase dramatically in numbers. They may occur in hot-spots and sometimes only a few trees on the edge of the orchard may be defoliated.

Monitoring: Monitor new leaves in the early morning and evening, particularly during late wet season to flowering.

J	F	M	A	M	J	J	A	S	O	N	D

Above: Adults
Below: Damage showing skeletonising and browning of leaves

Swarming leaf beetles

Rhyparida sp., *Geloptera aequalis* (Family Chrysomelidae)

Description:

Eggs: Unknown (not normally seen).

Immatures: Larvae feed on grass roots and pupate in the soil (the larvae are not usually seen).

Adults: Rhyparida - golden brown to black in colour with an oval shaped body. Size: 7–8 mm in length.

Adults: Geloptera - glossy black with a metallic sheen.
Size: 4–5 mm in length.

Life Cycle: Adults emerge after the first rains at the onset of the wet season.

Similar to: A wide variety of solitary beetles.

Damage: Adults prefer to feed on new leaves but may also damage bark. Large swarms may strip extensive patches of new growth causing significant leaf loss. Leaves will be completely eaten or they may be skelentonised and become brown and dried.

Critical Control period: November to March.

Other comments: Beetles may appear suddenly and in large numbers. May occur in hot spots on one or several trees rather than evenly spread throughout the orchard. They feed on a wide range of hosts.

Monitoring: Monitor new leaves in the early morning and evening, particularly during late wet season to flowering.

J	F	M	A	M	J	J	A	S	O	N	D

Above (L): *Rhyparida* sp. **Above (R):** *Geloptera aequalis*
Below: Damage to leaves

Dimpling bug

Campylomma austrina (Family Miridae)

Description:

Eggs: Unknown (not normally seen).

Immatures: Nymphs are pale yellow and similar to adults.

Adults: Oval, pale green to pale yellow and very active.
Size: 2.5 mm in length.

Life Cycle: Eggs are laid onto flowers and developing fruit. Nymphs hatch and go through five instars before moulting into an adult. Development from egg to adult takes approximately 2 weeks.

Similar to: A variety of bugs in the same family.

Damage: Adults and nymphs suck sap from flowers and developing fruit which initially causes slight pitting and pimpling, and may cause dimpling in the later stages of fruit development. Most of this damage grows out.

Critical control period: Flowering and fruit set.

Other comments: Nymphs and adults are both sap feeders and predatory.

Monitoring: To determine the presence of bugs, lightly tap the flower panicle onto a piece of paper and examine with a hand lens.

J	F	M	A	M	J	J	A	S	O	N	D

Above: Adult
Below: Fruitlet with dimpling damage

Fruitspotting bug

Amblypelta lutescens lutescens (Family Coreidae)

Description:

Eggs: Pale green and wedge-shaped. Size: 2 mm in length.

Immatures: Nymphs have a black head with long antennae and a light green tear-drop shaped body with a red patch and two black dots.

Adults: Light green with a light brown back (which includes the folded wings). Size: 15 mm in length.

Life Cycle: Eggs are laid singly on young shoots and leaf petioles. Once hatched the nymph goes through five instars before moulting into an adult. Development from egg to adult takes approximately 40–45 days. There may be 4–5 generations per year.

Similar to: The damage may appear similar to that of tea mosquito bug.

Damage: Nymphs and adults suck sap from shoots and young fruit. When new pink shoots are attacked they wilt and die. Symptoms of attack in green shoots and young fruit are black marks where feeding has taken place. These marks later appear as elongate brown lesions which crack as the shoot or fruit expands during growth.

Critical Control Period: Periods during the late wet season and early dry season when leaf flushes appear.

Monitoring: Check young shoots for lesions at least once a week. Adults and nymphs are difficult to find.

J	F	M	A	M	J	J	A	S	O	N	D

Above (L): Nymph **Above (R):** Adult
Below: Old lesions on stem

Graptostethus bugs

Graptostethus spp. (Family Lygaeidae)

Description:

Eggs: Unknown (not normally seen).

Immatures: Similar to adult but smaller (not normally seen).

Adults: Orange-red with a 'cross' pattern made by the folded wings. Size: 7–9 mm in length.

Life Cycle: Development time from egg to adult is 45–81 days. Eggs take 14–21 days to hatch, nymphs develop in about 30 days, adults live for about 80 days.

Similar to: A variety of similarly coloured swarming bugs.

Damage: May occur on flowers and shoots in very large numbers but they do not feed on fruit trees. Some scratch marks may be seen on trees affected by large swarms.

Critical Control Period: Spray only if there is physical damage to flowers, scratching damage to fruit, or the likelihood of structural damage to branches.

Other comments: Four species are recorded from the Northern Territory. These bugs feed on seed pods of some field crops, native plants and weeds.

Monitoring: Look for swarms in flowers and on leaves.

J	F	M	A	M	J	J	A	S	O	N	D

Above: Adult
Below: Adults on a flower panicle

Tea mosquito bug

Helopeltis pernicialis (Family Miridae)

Description:

Eggs: Elongate, white and embedded in plant tissue (rarely seen).

Immatures: Similar in appearance to adults, golden brown in colour.

Adults: Adults are dark reddish brown or black with an orange thorax and a white underside. They have a prominent spine on the centre of the thorax. Legs are long, black and thin. Antennae are longer than the length of the body. Size: 6–7 mm in length.

Life Cycle: Egg to adult takes about 30 days.

Similar to: Damage caused by bacterial black spot or pre-harvest anthracnose on immature fruit.

Damage: Feeding by both nymphs and adults produces black necrotic lesions on soft leaves, young shoots, flower panicles and developing fruit. Damage is very localised.

Critical Control Period: Late wet season to harvest.

Other comments: Tea mosquito bug prefers trees with dense foliage. Adults and nymphs are rarely seen, therefore it is easier to monitor for damage symptoms instead of the number of bugs.

Monitoring: Check for damage to new flush or developing fruit.

J	F	M	A	M	J	J	A	S	O	N	D

Above: Adult
Below: Spotting damage on developing fruit

Mango leafhopper

Idioscopus nitidulus (Family Cicadellidae)

Description:

Eggs: Cigar-shaped, creamy-yellow in colour. Size: 0.9–1 mm in length.

Immatures: Nymphs greenish with black or brown markings, resemble small adults but without wings.

Adults: Usually golden-brown or dark brown in colour, wedge-shaped similar to a very small cicada. Size: 4–5 mm in length.

Life Cycle: Adults breed throughout the year, however, during the flowering and fruiting period, reproduction and development is faster. Eggs are inserted into the mid-rib of new leaves and flower panicles and hatch in 2–3 days. Nymphs take 12–20 days to develop into adults.

Similar to: Mango planthopper damage.

Damage: Adults and nymphs feed on vegetative flush tissue by sucking the sap. Feeding and egg laying cause curling and distortion of new flush and young leaves. When populations are high, leaves and flowers may have a sticky wet appearance which is from the copious amount of honeydew the leafhoppers produce. Presence of sooty mould which grows on honeydew may also be an indication of leafhopper infestation.

Control Strategies: Monitor and treat infestations before flowering. Native lacewing larvae and other predators may assist in controlling immature leafhoppers.

Monitoring: It is especially important to monitor before and during flowering. Monitor for infestation and damage on flowers and new flush. In high numbers the leafhoppers make a characteristic clicking sound.

J	F	M	A	M	J	J	A	S	O	N	D

Above: Adults (winged) and nymphs **Inset:** An egg inserted into the mid-rib of a leaf
Below: Leaf curling, honeydew and sooty mould on leaves and flowers

Mango planthopper

Colgaroides acuminata (Family Flatidae). Also known as Flatids

Description:

Eggs: Laid in an oval-shaped raised mass, usually on leaves or fruit.

Immatures: Newly hatched nymphs are pale green with red markings. As they mature nymphs become pale green all over with a pointed head and white waxy filaments protruding from the end of the abdomen. Nymphs are covered with a white waxy material.

Adults: Green or whitish-green in colour and 'tent' shaped. A tiny red spot may be seen in the centre of each wing. Size: 10–15 mm in length.

Life Cycle: Adults breed all year round. Eggs hatch in 6–7 days. The nymphs take 12–16 days to develop into adults and their development is faster during the fruiting period. There are 3–4 generations per year.

Similar to: Other species of planthoppers.

Damage: Adults and nymphs suck sap from the shoots, flowers and fruit. Often seen along the mid-rib of leaves or on the fruit stalk. Flatids feeding on the fruit stalk may cause sap to flow on to the fruit which may lead to sapburn. Sooty mould and sapburn may affect marketability of fruit.

Control Strategies: Prune to reduce dense tree canopy as this assists in control. Spray programs are directed towards reducing the population level before flowering and fruit development. Native wasp parasites, parasitic caterpillars and fungal pathogens may assist in control.

Other comments: Adults and nymphs move or jump quickly when disturbed. Other species of planthoppers such as *Siphanta* are also seen on mangoes.

Monitoring: Monitor terminal shoots in the period leading up to flowering and inspect fruit stalks during fruit development for egg masses and nymphs.

J	F	M	A	M	J	J	A	S	O	N	D

Above (L): Adult on fruit stalk **Above (R):** Exuding sap caused by feeding
Below (L): Nymphs on leaf **Below (R):** Egg Mass

Flower caterpillars

(Family Geometridae, Lymantriidae, Noctuidae, Pyralidae, Tortricidae)

Description: There are at least 9 species of caterpillars that feed on flower panicles.

Eggs: Usually circular or oval in shape. Vary in colour.

Immatures: Caterpillars are assorted colours and sizes, usually small and hard to see when they first hatch. Caterpillars can grow up to 15 mm in length.

Adults: Moths are small, usually grey or brown in colour and nocturnal.

Life Cycle: Eggs are laid singly on flowers and hatch after 1–2 days into caterpillars. One generation takes up to 30 days to develop into adults during the flowering period. Caterpillars may occur on trees at different times if there is more than one flowering period.

Similar to: The webbing is similar to that of small spiders in flower panicles, but contains faecal matter.

Damage: Caterpillars web clusters of flowers together as they feed, forming matted silk and debris (frass) where they eventually pupate. They may also damage leaves and young fruit.

Control Strategies: A registered insecticide (that has a minimal effect on pollinators) which is applied while the caterpillars are newly hatched or at a young stage is sufficient to reduce populations. Multiple or extended flowerings favour the build-up of populations.

Monitoring: Inspect flowers every 2–3 days for webbing or larvae.

J	F	M	A	M	J	J	A	S	O	N	D

CATERPILLARS

Above (L): Noctuidae caterpillar **Above (R):** Geometridae caterpillar
Below: Dead flowers full of silken webbing

Large mango tip borer

Also known as Mango shoot caterpillar

Penicillaria jocosatrix (Family Noctuidae)

Description:

Eggs: Circular and yellowish in colour.

Immatures: Larvae are yellow-green with pink spots and turn pinkish-purple as they mature. Size: 25 mm in length.

Adults: Moths are russet brown with light coloured markings on the forewings. Hind wings are white with brown margins. Size: Wing span up to 25 mm.

Life Cycle: Eggs are laid singly on the underside of new flush leaves. Larvae hatch after 3–5 days. Larval development takes about 8–10 days. When mature larvae fall to the ground to pupate amongst the soil and mulch, adults emerge after 16–20 days.

Similar to: Caterpillars in the family Tortricidae feed in the stem of new shoots and rolled up leaves.

Damage: Larvae feed mainly at night on the new flush before it changes from purple to green. Immature larvae feed on the leaf surface around the edges, which produces a window-like effect. As larvae mature the entire leaf may be eaten, giving them a ragged edge or skeletonised appearance. When infestations are high, larvae will feed on the growing tips of shoots. If larvae attack pre-flowering flush it can lead to multiple vegetative shoots. They may also damage flower panicles and fruitlets.

Critical Control Period: If necessary, monitor and treat the flush growth during the late wet season and early dry season.

Monitoring: Both surfaces of the new flush and mature leaves should be inspected for eggs and larvae in the evening when caterpillars are more active. Look for fresh caterpillar droppings or frass on new flush growth.

J	F	M	A	M	J	J	A	S	O	N	D

CATERPILLARS

Above (L): Larvae showing colour variations **Above (R):** Adult
Below: Leaf chewing damage

Mango fruit borer

Citripestis eutraphera (Family Pyralidae)

Description:

Eggs: Newly laid eggs are white and turn red after 1 day. Size: 1 mm in diameter.

Immatures: Newly hatched larvae are pale pink with a dark brown to black head. Young larvae are pale pink-brown in colour with 4 bands of black spots that run along the body. As the larvae become mature they darken to red brown. Size: up to 15 mm in length.

Adults: The forewings are dark brown and the hindwings are pale white-grey with a grey band around the margin. Size: Wing span: female 24 mm, male 20 mm.

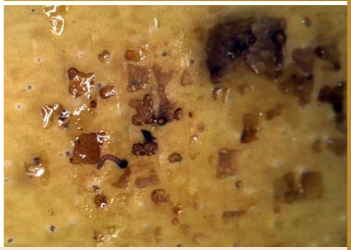
Life Cycle: Eggs take 2–3 days to hatch. Once hatched, the larvae take 14 days to mature and pupate. After 14 days, the adult emerges. In captivity, adults live for up to 10 days.

Similar to: Other moths, particularly those in the family Pyralidae.

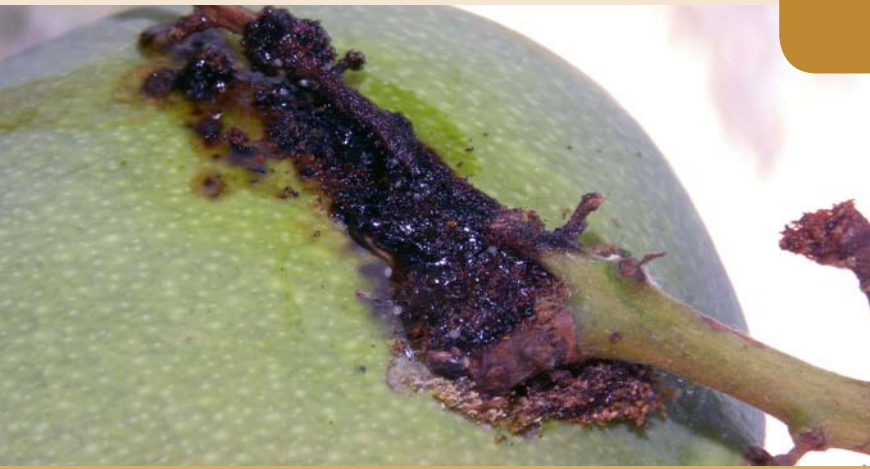
Damage: Eggs are laid on the skin around the stem end of the fruit or on the skin within the top third of the fruit. If two fruit are hanging on the tree and touching, eggs are sometimes laid on the skin surface where the two fruit make contact. Wet looking frass is seen on the outside of the fruit. After hatching, the larvae will initially feed by chewing the surface of the skin of the fruit and then tunnel into the flesh.

Monitoring: Inspect immature and mature fruit on the trees as well as fallen fruit for holes with frass.

J	F	M	A	M	J	J	A	S	O	N	D



Above (L): Eggs **Above (R top):** Immature larva
Above (R bottom): Recently hatched larva feeding on fruit
Below: Feeding damage and frass around stem end



Mango stem miner

Spulerina isonoma (Family Gracillariidae)

Description:

Eggs: Unknown (not normally seen).

Immatures: White with brown head and distinct body segmentation.

Adults: Speckled grey with transverse white lines on forewings (markings visible with a hand lens). Size: 4 mm in length (not normally seen).

Life Cycle: Probably 3–4 weeks, adults possibly live for up to 5 months.

Similar to: Nil

Damage: A white-grey coloured papery 'blister' is formed on the stem of new shoots as the larva feeds under the epidermis. Usually the damage does not kill the shoot as the larva only feeds partly around the circumference of the stem and rarely causes ringbarking.

Critical Control Period: Consider control if damage to vegetative shoots is greater than 10% in the late wet season.

Monitoring: Inspect stems of new shoots for papery blisters.

J	F	M	A	M	J	J	A	S	O	N	D

CATERPILLARS

Above: Larva
Below: Papery 'blisters' on stem

Fruit Flies

(Queensland Fruit Fly[1] and Jarvis'[2] Fruit Fly)

Bactrocera tryoni[1] and *B. jarvisi*[2] (Family Tephritidae)

Description:

Eggs: Creamy white. Size: 1 mm in length.

Immatures: White or cream coloured maggots with a black tooth-like feeding mouth part. Size: up to 8 mm in length

Adults: Red-brown or yellow-brown with yellow markings on the body. Size: 9–10 mm in length.

Life Cycle: Females lay clumps of 6–10 eggs just under the skin of the fruit. Larvae hatch from the eggs after 1–2 days and take 6–8 days to mature at which time they pupate. After 10–12 days the adults emerge and may live for up to a few months.

Similar to: Other fruit flies. Not to be confused with the much smaller vinegar flies.

Damage: Both species of fruit flies infest a range of commercial and native fruits. External damage to fruit is seen as sting marks or bruising to the skin. Once hatched, larvae tunnel through the fruit causing decay of the flesh. Fruit are more likely to be attacked when they start to ripen. Kensington Pride fruit harvested at the correct maturity stage are generally not infested.

Control Strategies: Refer to Interstate Certification Assurance (ICA) conditions.

Monitoring: Fruit fly lure traps only attract male flies and may be used to indicate the types of fruit flies present but do not control or eradicate the population. Inspect fruit for sting marks. Adult females may be seen on mature fruit.

J	F	M	A	M	J	J	A	S	O	N	D

Above: Larva and damage to fruit flesh
Below: Adult female laying eggs

Mealybugs

(Citrus Mealybug[1] and Striped Mealybug[2])

Planococcus citri[1], and *Ferrisia virgata*[2] (Family Pseudococcidae)

Description:

Eggs: Citrus mealybug - Pink, oval shaped and laid in a cottony mass.

Immatures: Citrus mealybug - Yellow, oval shaped, flat and similar to the adult but much smaller and more mobile. Striped mealybug - Yellow in colour with a white powdery coating and the stripes are not developed.

Adults: Citrus mealybug - Females are wingless, oval shaped with a light pink body covered in white waxy filaments on and around the edges of the body. Males are small and winged. Size: up to 4.5 mm in length.

Adults: Striped mealybug - Females have two distinct dark stripes on the back and are covered in a white powdery coating with shiny white waxy filaments around the edge of the body and two long waxy tails extending from the end of the body. Males are winged with two long white tails. Size: 2–5 mm in length.

Life Cycle: Crawlers may hatch within one to two days after egg laying and then disperse across the plant looking for a protected feeding site. Crawlers go through three to four moulting stages before becoming adults. The males have wings and do not feed. Development from egg to adult is up to 42 days.

Similar to: Fluted scales and other mealybugs.

Damage: Mealybugs feed by sucking sap from leaves, flowers, stems and fruit. Leaves become distorted, yellow, stunted and may drop. Stems and fruit become covered in white wax and sooty mould grows on the honeydew they secrete.

Control Strategies: Ants form a beneficial relationship with mealybugs and will 'farm' them for the honeydew that they produce. Ants may need to be treated or managed.

Monitoring: Check leaves, stems and fruit for mealybugs and sooty mould.

J	F	M	A	M	J	J	A	S	O	N	D

MEALYBUGS

Above (L): Citrus mealybug on stem **Above (R):** Citrus mealybug on fruit
Below: Striped mealybug adults and crawlers

Mango bud mite

Aceria mangiferae (Family Eriophyidae)

Description:

Eggs: Laid on leaves or leaf buds. Spherical or elliptical and colourless or translucent. Size: about 20–60 µm in diameter.

Immatures: Similar to adults but smaller.

Adults: Whitish and torpedo shaped, not visible to the naked eye. Size: 0.25 mm in length.

Life Cycle: Eggs hatch within a few days and the life cycle from egg to adult takes about 6 days.

Similar to: Mango malformation symptoms.

Damage: Produces distortion, stunting and bud proliferation of new growth. The mites may transmit mango malformation disease.

Critical Control Period: Prune distorted new growth in the early dry season.

Monitoring: Inspect trees for distorted new leaf buds or shoots. These symptoms may be caused by the mango malformation disease. The presence of bud mite or mango malformation disease can only be diagnosed by microscopic examination or a diagnostic test.

J	F	M	A	M	J	J	A	S	O	N	D

MITES

Above: Mites on mango leaf bud **Inset:** Mango bud mite X400 magnification
Below: Damage to mango shoot

Mango leaf coating mite

Cisaberoptus kenyae (Family Eriophyidae)

Description:

Eggs: Pale white, round and flattened.

Immatures: Similar to adults.

Adults: Pale white to creamy orange in colour, torpedo shaped. Size: 0.2 mm in length.

Life Cycle: Unknown.

Similar to: N/A.

Damage: Mites feed on the leaves under a white waxy coating on the upper leaf surfaces.

Control Strategies: These mites generally only occur on over-grown or neglected mango trees. Pruning to increase ventilation is usually enough to discourage or reduce infestations.

Monitoring: Look for leaves covered in a white waxy coating.
Prune affected shoots after harvest.

J	F	M	A	M	J	J	A	S	O	N	D

MITES

Above: Mites feeding on leaf
Below: Waxy coating on leaves

Fluted Scales

(Egyptian Fluted Scale[1] and Seychelles Scale[2])

Icerya aegyptiaca[1] and *I. seychellarum*[2] (Family Margarodidae)

Description:

Eggs: Pale in colour and ovoid, found under the mature female.

Immatures: Egyptian fluted scale - oval shaped orange body covered in fluffly white wax.

Immatures: Seychelles scale - oval shaped, orange body covered in pale yellow wax and glass-like filaments.

Adults: Egyptian fluted scale - oval shaped, orange body covered in fluffy white waxy filaments with six black legs.

Adults: Seychelles scale - oval shaped, orange body with black legs. Body covered in a white waxy coating. There are two ridges covered with fluffy yellow wax around the margin of the body and a ridge along the top of the body. Size: 3–8 mm.

Life Cycle: At least 6 generations per year.

Similar to: A variety of other mealybugs which differ slightly in wax pattern and colour.

Damage: Fluted scales suck sap from stems, shoots and leaves.

Critical Control period: Check new shoots in the early dry season and pre-flowering.

Other comments: Fluted scales occur on a wide range of plants. Parasitic wasps do not appear to be abundant. The pattern and colour of wax on the fluted scales assists in identification, but is easily rubbed off and may make species identification difficult. Predatory beetles such as *Cryptolaemus montrouzieri* (found naturally and also available from suppliers) are effective in controlling immature stages.

Monitoring: Inspect leaves, leaf petioles, stems, fruit and fruit stalks for fluted scales. If infestations are present at the start of the dry season, these need to be managed before flowering.

J	F	M	A	M	J	J	A	S	O	N	D

Above (L): Egyptian fluted scale **Above (R):** Seychelles scale
Below: Infestation on shoot

Mango Scales

(False Mango Scale[1] and White Mango Scale[2])

Pseudaulacaspis nr. *cockerelli*[1] and *Aulacaspis tubercularis*[2]
(Family Diaspididae)

Description:

Eggs: The eggs are laid in clusters, ovoid and found under the mature female. False mango scale - eggs are yellow. White mango scale - eggs are red.

Immatures: False mango scale - crawlers are yellow. Late instars are similar to adults.

Immatures: White mango scale - crawlers are pink or red. Late instars are similar to adults.

Adults: False mango scale - females are yellow with scale covers that are flat, white and pear-shaped with a yellow-brown coloured caste skin attached. Size: 1–2 mm.

Adults: White mango scale - females are red with scale covers that are flat, white and circular with a black oval shaped caste skin. Size: 1–2 mm.

Males of both species are white, rectangular in shape with two or three distinct ridges. Many males are usually clustered around a single female. Adult males have wings and are capable of flight.

Life Cycle: 5–6 generations per year.

Similar to: Diaspid scales on other fruit trees, ornamentals and mature plants.

Damage: Adults of crawlers suck sap from leaves and fruit. Feeding areas on leaves turn pale green or yellow. Damage on fruit is seen as pink blemishes.

Critical Control Period: Pre-flowering and after harvest.

Other comments: Parasitised by a variety of small wasps. Their presence is indicated by a small emergence hole in adult scales.

Monitoring: Check the upper surface of hardened leaves for scales.

J	F	M	A	M	J	J	A	S	O	N	D

Above (L): Scales on leaf **Above (R):** False mango scale
Below: Yellow blotches on leaves caused by false mango scale

Pink wax scale

Ceroplastes rubens (Family Coccidae)

Description:

Eggs: Orange-red and ovoid, found under the mature female.

Immatures: Crawlers are pale pink with legs. Older instars are similar to the adult but smaller and star-shaped.

Adults: Covered in pinkish-brown wax and almost globular shaped with two pairs of white bands on the edge of the scale cover. Size: 3–4 mm across.

Life Cycle: Most stages of the life cycle are found throughout the year.

Similar to: Fig wax scale.

Damage: Adults and nymphs suck sap from leaves, stems and fruit stalks. Scales excrete honeydew onto the leaves on which sooty mould grows, reducing the ability of the tree to photosynthesise. Pink wax scale is rarely seen in commercial orchards but occasionally seen on backyard trees.

Critical Control period: Treat immature stages when crawlers move and settle onto hardened flush. Treat only when scale populations are high.

Other comments: A variety of small naturally occuring wasps assist in controlling scales. Parasitised adult scales appear darker or have a small emergence hole. Inappropriate chemical use may cause an increase in the population of scales.

Monitoring: Inspect shoots and leaves for live scales, especially mature females with eggs (under the scales) and crawlers nearby. Also inspect leaves for parasitised scales.

J	F	M	A	M	J	J	A	S	O	N	D

SCALES

Above: Pink wax scales on a leaf with sooty mould
Below: Shoots with pink wax scales and sooty mould

Giant northern termite

Mastotermes darwiniensis (Family Mastotermitidae)

Description:

Eggs: Laid in rafts, are small, elongate and cream in colour.

Immatures: Similar to workers but smaller.

Adults: There are several different castes:

Workers - soft bodied, off-white in colour and often the gut contents can be seen through the body wall. Size: 10–11.5 mm in length.

Soldiers - soft bodied with an off-white coloured body and an orange/brown head with large mandibles. Size: 11–13 mm in length.

Winged reproductives - dark brown with wings. Size: 35 mm including wings.

Primary reproductives - dark brown with severed wings. Size: 15 mm.

Secondary reproductives - these are slightly larger than workers and are dark brown all over and without severed wings.

Workers, soldiers and secondary reproductives are completely blind, while nymphs and primary reproductives have distinct eyes.

Life Cycle: Eggs hatch into nymphs which develop into winged reproductives or larvae which develop into workers or soldiers. After a mating flight, the winged reproductives lose their wings and become kings and queens (primary reproductives) but these are rarely seen. Workers can also change into secondary reproductives which are more common. The soldiers and workers can live for 1–2 years.

Damage: This termite has subterranean colonies and bores into trees from underground, and there are often no external signs of attack. Early symptoms are wilting and drying of leaves followed by the death of shoot tips or whole branches.

J	F	M	A	M	J	J	A	S	O	N	D

Above (L): Workers, soldier and egg raft **Above (R):** Ringbarking damage to trunk

Often trees are ring-barked and mudded up around the base or crutch of the tree and there will be dead branches which often look like hollow folded tubes. In advanced infestations there will be reduced vigour of the whole tree and in some cases death.

Monitoring: Look for the symptoms described under **'Damage'**. To detect giant termite activity, drill a hole approximately 12 mm (in diameter) into the centre of the trunk at waist height. If termites are active they will seal this hole with mud on the outside after 24 hours.

Critical Control Period: As soon as an infestation is detected. Treating trees with confirmed infestations will often stop damage to nearby infested trees in which symptoms are not yet evident.

Flower thrips

Various species such as *Thrips imaginis, Thrips hawaiiensis, Thrips unispinus, Thrips coloratus, Frankliniella schultzei,* (Family Thripidae) and *Haplothrips bituberculatus, Haplothrips frogatti* and *Haplothrips haideeae* (Family Phlaeothripidae)

Description:

Eggs: Kidney-shaped and soft, inserted singly into or onto plant tissue.

Immatures: Similar to adult in shape, usually yellow in colour with dark hairs on tip of abdomen. *Halothrips* have red stripes.

Adults: Elongate, yellow, brown or bi-coloured with feather-like wings. Size: 1 mm in length.

Life Cycle: The complete life cycle from egg to adult is approximately 21 days.

Similar to: Other thrips which may be found in flowers or on leaves.

Damage: Most species are pollinators and are unlikely to damage flowers or developing fruit. Occasionally nymphs have been noticed on very small fruitlets (less than 15 mm) associated with minor damage.

Critical control period: Unlikely to require control.

Other comments: The identification of thrips to species level requires microscopic examination. Flower thrips are common on many native flowering plants.

Monitoring: To determine the presence of thrips lightly tap the flower panicle onto a piece of paper and examine this with a hand lens.

J	F	M	A	M	J	J	A	S	O	N	D

Above (L): Thrips larva on flowers **Above (R):** *Haplothrips* sp. adult,
Below (L): *Frankliniella schultzei* adult **Below (R):** *Thrips hawaiiensis* adult

Redbanded thrips

Selenothrips rubrocinctus (Family Thripidae)

Description:

Eggs: Kidney shaped and inserted singly into soft leaf tissue usually near the mid-rib, and covered with a drop of fluid which dries to black.

Immatures: Nymphs are creamy yellow in colour with two bright red bands around the abdomen. Size: up to 1 mm.

Adults: Dark brown to black in colour with wings. Adults are predominantly female. Size: 1–1.3 mm in length.

Life Cycle: Nymphs hatch within 4 days of egg laying and pass through two instars lasting 9–10 days. At maturity the nymphs go through two pupal stages which last 3–5 days before the adult emerges. Development from egg to adult takes 14–21 days. Adults live for up to 30 days.

Similar to: Other dark coloured thrips on leaves and flowers.

Damage: Mostly on the underside of new flush, hardened leaves and sometimes fruit. They rasp and suck the sap from leaves and fruit giving it a silvery sheen. In severe infestations the leaves are covered in faecal spots and appear yellow-brown or dried and burnt. Damaged fruit has patches of brown scarring.

Control Strategies: A range of natural enemies are present in orchards including lacewings, spiders and predatory thrips. Spot spraying will often be sufficient.

Other comments: These thrips have a wide host range and may also infest other fruit trees, ornamentals and native plants. Sometimes the source of infestation may originate from plants in bushland outside the orchard.

Monitoring: Examine the underside of the leaves for thrips or black droppings using a hard lens. Mango trees along the edges of the orchard may become infested first, therefore, these are important trees to monitor.

J	F	M	A	M	J	J	A	S	O	N	D

THRIPS

Above (L): First instar nymphs showing red stripes **Above (R):** Adult
Below: Damage showing scarring and dried leaves

Chilli thrips

Scirtothrips dorsalis (Family Thripidae)

Description:

Eggs: Pale yellow, kidney shaped and inserted into leaf tissue (not normally seen).

Immatures: Pale yellow, similar shape to adult. Size: up to 0.8 mm.

Adults: Pale yellow with dark antennae, dark stripes on the back of the lower abdomen and dark feathery wings. They are very active. Size: 0.8 mm in length.

Life Cycle: Development from egg to adult takes up to 21 days.

Similar to: Other pale coloured thrips.

Damage: Adults and nymphs feed by rasping and sucking sap from soft flush leaves. The damage can be seen as brown scarring on the leaves.

Other Comments: These thrips have been noticed on flush leaves on the occasional mango tree in the Darwin rural and Katherine areas. This damage is very similar to redbanded thrips damage.

Monitoring: Check the upper surface of young leaves for nymphs and adults.

J	F	M	A	M	J	J	A	S	O	N	D

THRIPS

Above (L): Second instar nymph **Above (R):** Adult
Below: Brown scarring to flush leaves

MANGO
Field Guide

Beneficials

Green tree ant

Oecophylla smaragdina (Family Formicidae)

Targeted pests: A range of slow moving insects such as caterpillars, beetles and many others.

Description:

Eggs: White and oblong. Size: about 0.4 mm in length.

Immatures: Larvae are grub-like and white. Pupae are white and found inside nests.

Adults: Workers and queens have a yellow head and thorax with a green abdomen. Queens may have wings when they disperse. Size: Adult worker 7–9 mm in length, queen 15–21 mm in length.

Biology and predatory activity: Development from egg to adult (worker) is 30 days.

Green tree ants live in nests made by weaving leaves together with larval silk. Colonies generally consist of many nests. Not all nests contain queens.

They predate on insects such as caterpillars and leafhoppers but also supplement their diet with honeydew obtained from sap feeders, such as mealybugs and scales that they tend. An alternative food source is nectar from flowers.

Pests that are tended and protected by green tree ants may cause damage to trees. Occasionally in areas where there is a high population of green tree ants, black spots may be seen on the fruit. This is caused by formic acid which the ants spray when threatened. Green tree ants can be a major nuisance at harvest, large populations may need to be 'thinned out' by removing nests.

J	F	M	A	M	J	J	A	S	O	N	D

ANTS

Above: Workers on fruit
Below: Workers attacking a caterpillar

Red meat ant

Iridomyrmex sanguineus (Family Formicidae)

Targeted pests: A range of slow moving insects such as caterpillars and beetles.

Description: Red-brown thorax with a green-black abdomen. Size: 5–10 mm in length.

Biology and predatory activity: The complete life cycle takes about 28 days. These ants are predatory but they also feed on nectar as well as tending scales, mealybugs and fluted scales for honeydew. In situations when natural food sources are not available and in drier areas, red meat ants can chew the margins of young leaves and are sometimes regarded as pests.

These ants are usually seen near nests on bare ground or foraging on plants for honeydew-secreting insects or various prey species.

J	F	M	A	M	J	J	A	S	O	N	D

ANTS

Above: Worker
Below: Workers chewing the margins of new flush leaves

Mealybug ladybird

Cryptolaemus montrouzieri (Family Coccinellidae)

Targeted prey: Adults and larvae feed on mealybugs, fluted scales and certain scales in the family Coccidae such as *Pulvinaria*. In all situations, eggs and small immature stages are preferred.

Description:

Eggs: Yellow in colour and laid into the egg masses of mealybugs, fluted scales or soft scales.

Immatures: Larvae are grey on the underside with six black legs and have fluffy white wax on the top side of their body. Size: 7–8 mm in length.

Adults: Oval-shaped beetles with black wing covers and an orange head and rear end. Adults can crawl rapidly and also disperse by flying. Size: 4.5 mm in length.

Biology and predatory activity: Development from egg to adult takes 28–49 days. Adults can live for up to a few months.

Mealybug ladybird larvae look similar to mature mealybugs or fluted scales. How do you tell them apart? Mealybug ladybirds are fast moving, the underside of the body is grey, have well developed legs and chewing mouth parts. Mealybugs and fluted scales are orange or yellow on the underside of their body and they generally do not move after they insert their mouth parts into the plant tissue to feed. The mealybug ladybird is a native predator but can also be purchased from a supplier. Orchards should not be sprayed with pesticides immediately before releasing this predator.

J	F	M	A	M	J	J	A	S	O	N	D

BEETLES

Above: Adults foraging on a leaf
Below: Larva feeding on a scale (Coccidae)

Hover fly larvae

(Family Syrphidae)

Targeted prey: Aphids, mealybugs and whiteflies.

Description:

Eggs: Small eggs usually deposited on, or near the host insect.

Immatures: Larvae are 'maggots', which are generally white or brownish in colour or green with two white stripes along the length of the body. The body tapers towards the head.

Adults: Stout or slender bodied with a large head and eyes. Yellow and black bands or spots are usually seen on the body. Size: 8–20 mm in length. A photo of an adult hover fly is shown on page 87.

Biology and predatory activity:

Development from egg to adult takes between 2–6 weeks.

Hover fly larvae are predatory and the adults are pollinators. The larvae are often seen on plants that are heavily infested with aphids, mealybugs or whiteflies. Other species of hover fly larvae live in rotting vegetation. Some larvae are aquatic such as the rat-tailed maggots.

FLIES

Above: Larva feeding on citrus mealybug
Below: Larva

Parasitic flies

(Family Tachinidae)

Targeted prey: Caterpillars, beetle larvae and grasshoppers.

Description:

Eggs: Small eggs usually deposited on, or near the host insect.

Immatures: Larvae are endoparasitic (internal parasites) in insects.

Adults: Stout bodied, usually with bristles. Common colours include grey, black or blue with markings. Size: up to 35 mm wingspan.

Biology and parasitic activity: The complete life cycle from egg to adult takes about 4 weeks. Eggs or larvae are laid directly on (but rarely in) the host. Larvae may be deposited near the host so that they can easily gain access. In some species, tiny eggs are laid on the host's food plant and if ingested these hatch and the larvae penetrate the host's gut wall. These flies parasitise their prey and the larval stage eats the inside contents (of the host), killing them slowly, so that they have time to pupate before the host dies. Some flies leave the host and pupate in the soil, others can pupate within the host.

It is difficult to monitor immature stages, however, adult tachinid flies may be seen pollinating flowers.

FLIES

Above: Tachinid fly
Below: A tachinid fly laying an egg onto a caterpillar

Green lacewing

Mallada signata (Family Chrysopidae)

Targeted prey: Larvae are general predators and feed on insects such as redbanded thrips, scales, mites, aphids, immature mealybugs, immature fluted scales, moth eggs and small caterpillars.

Description:

Eggs: White, oval shaped and on stalks.

Immatures: Larvae have large piercing mandibles for capturing prey and are camouflaged with remnants of dead prey which they place onto their backs. Size: 1–8 mm in length.

Adults: Green body with 2 pairs of delicate transparent wings. Size: Up to 14 mm in length including wings.

Biology and predatory activity:

Development from egg to adult is up to 25 days. Eggs take about 4 days to hatch, larvae moult 3 times over 12 days, the pupal period is about 9 days. Adults live for up to 30 days.

Many species of lacewings are found naturally in orchards. Green lacewings can be purchased from a commercial supplier. As some pesticides affect lacewings, it is recommended that residual pesticides should not be applied for 3–4 weeks before release.

When looking for lacewings, check for eggs which are attached to leaves, larvae may be seen foraging. Adults are not usually seen during the day but are often seen attracted to lights at night.

J	F	M	A	M	J	J	A	S	O	N	D

LACEWINGS

Above: Green lacewing larva (with remnants of prey on its back) approaching a thrips
Below (L): Green lacewing eggs **Below (R):** Adult on a leaf

Planthopper Parasitic Moth

Heteropsyche sp. (Family Epipyropidae)

Targeted prey: Planthoppers.

Description:

Eggs: Circular and transparent (not normally seen).

Immatures: Mature larvae are rounded and arched in shape. They have a white waxy or powdery appearance (not normally seen).

Adults: Dark grey. Size: 10–15 mm wingspan.

Biology and parasitic activity: Development from egg to adult takes about 30 days.

Planthopper parasites lay eggs on the leaves and fruit. The first instar larva is mobile and stands in an upright position on the leaf, waving from side to side waiting for a planthopper to fly by. Once attached to a planthopper it hangs on with its hooked claws and strands of silk and feeds on the planthopper body fluids. When mature the larva releases itself from the planthopper and 'crochets' a cocoon on a leaf, stem or fruit. The pupal case looks like a small white rosette.

J	F	M	A	M	J	J	A	S	O	N	D

PLANTHOPPER PARASITES

Above: An adult which has recently emerged from a rosette pupal case
Below: An adult and rosette pupal case

Praying mantids

(Family Mantidae and others)

Targeted prey: Although mantids will catch and feed on pests such as planthoppers, moths and fruit spotting bugs, they will also attack other insects which are not pests, such as pollinators.

Description:

Eggs: Up to several hundred eggs are laid in an egg capsule called an ootheca which is usually attached to branches and trunks or sometimes logs and rocks.

Immatures: Resemble adults but do not have wings.

Adults: May vary in colour from green to light brown, elongate body form with a freely movable head with large eyes and strong jaws. The front legs are adapted for catching prey. Adults are usually winged, females usually have reduced wings or no wings, depending on the species. Size: 10–120 mm in length.

Biology and predatory activity: Praying mantids go through about two generations per year. Mantids are not usually in high enough numbers to be effective in controlling pest populations. Mantids can be found on the trunks, branches and in the canopy. Most species are coloured to blend in with their surroundings. Shoot dwellers are green and bark dwellers are mottled grey or brown. This camouflage hides the predator from the prey.

J	F	M	A	M	J	J	A	S	O	N	D

PRAYING MANTISES

Above: A praying mantid attempting to catch insects in a flower panicle
Below: Green mantid

Spiders

(Family Salticidae, Thomisidae, Oxyopidae, Araneidae and many others)

Targeted prey: A large range of flying and crawling insects such as redbanded thrips, planthoppers, caterpillars and moths.

Description:

Eggs: Eggs are produced in strong silken sacs, or in a silken mass curled in leaves or on the bark. The eggs are often protected by the female.

Immatures: Spiderlings are similar to adults but are usually smaller with variations in colour and markings.

Adults: Spiders have eight legs and two distinct body parts (cephalothorax and abdomen). They also have simple eyes (usually 8), silk producing organs and no antennae or wings. Spiders are of various sizes and colour, depending on the species.

Biology and predatory activity: The life cycle is variable according to the species. Spider webbing can be mistaken for flower caterpillar webbing. It is believed that spiders are less affected by orchard spraying than other beneficials. Spiders can be seen on most parts of the tree such as in flower panicles, on leaves or on the bark. They are often found in silken webs in curled leaves or in webs between shoots.

J	F	M	A	M	J	J	A	S	O	N	D

SPIDERS

Above (L): St. Andrews Cross spider **Above (R):** Thomisid spider
Below (L): Jumping spider, *Mopsus* **Below (R):** Lynx spider

Papernest, potter and mud dauber wasps

(Family Vespidae)

Targeted Prey: Insect larvae and spiders.

Description: (adults)

Papernest wasps, family Vespidae, subfamily Polistinae. These are social wasps, that are usually brown or black with yellow markings. They build papery nests out of chewed wood and saliva in layered combs which may be spiralling or enclosed in an extra layer. The nest may have hundreds of individuals (one fertile queen and many workers). The adults supply chewed up caterpillars for the larvae. Size: up to 20 mm in length.

Potter wasps, family Vespidae, subfamily Eumeninae. These are solitary wasps and are usually black or brown in colour with orange, yellow, white or red markings. Nests are either built out of mud and resemble a small pot, or they excavate burrows and they will also make use of abandoned burrows of other insects. Nests are supplied with paralysed larvae or spiders on which the wasp larva feeds. Size: up to 35 mm in length.

Mud dauber wasps, family Sphecidae. These are solitary wasps and are usually black with yellow or orange markings. Nests are built out of wet mud and are usually constructed in a line or cluster. Once the nest is built, the female wasp lays an egg on the paralysed spiders that she has placed in each cell for the hatched larva to feed on. Size: up to 35 mm in length.

Biology and predatory activity: All of these adult wasps feed on nectar.

Wasps may be seen foraging in crops or at their nests. All wasps can give a painful sting and may cause an allergic reaction which in some cases may be severe. As a precaution, it is best not to approach wasp nests.

J	F	M	A	M	J	J	A	S	O	N	D

WASPS

Above (L): Mud dauber wasp **Inset:** Nest **Above (R):** Potter wasp
Below (L): Papernest wasps **Below (R):** Papernest wasp, *Polistes schach*

Parasitic Wasps

(Family Encyrtidae, Eulophidae)

Targeted prey:

Family Encyrtidae: Pink wax scale and planthopper egg mass.

Family Eulophidae: Large mango tip borer and redbanded thrips.

Family Ichneumonidae: Large mango tip borer.

Family Braconidae: Longicorn beetles.

There are many other families of wasps that are also parasitic, however, the families mentioned are those which have been recorded from mango orchards.

Suitable crops or vegetation: Protected crops that are not wind exposed. Tree crops that are well established with a decent sized canopy may be more suitable for these parasites to establish. In all situations the wasps will have a greater chance of establishing if minimal or no pesticides are used.

Description, Biology and parasitic activity:

Adults: Family Encyrtidae and Eulophidae – these wasps are very small, 0.5–6 mm in length. The colour may vary according to the species. The species recorded from mango pests have a dark brown or black head and thorax with a white abdomen or are dark brown all over. They have large eyes and transparent wings.

Adults: Family Ichneumonidae – includes larger wasps, size range 1.5–120 mm in length. These wasps range in colour and size but are usually yellow or golden brown (some species may have black markings on the thorax or abdomen). The wasps have a slender body with long antennae, long abdomen and extended ovipositor. Eggs can be laid, near, on or in the host. These wasps generally attack larger hosts. Adult wasps may be seen at flowers or on dew in the early morning.

Adults: Family Braconidae – small to medium wasps from 1–80 mm in length. These wasps parasitise many different types of larvae (including beetle larvae, caterpillars and aphids) but eggs and adults may also be attacked. In mangoes they have been recorded as a parasite of longicorn beetle.

Development from egg to adult takes about 30 days. Adults are parasitic and attack the immature stages of targeted pests such as the egg or larvae. Regular spraying with persistent pesticides will reduce the levels of wasp parasites.

WASPS

Above (L): Encyrtidae **Above (R):** Eulophidae
Below (L): Ichneumonidae **Below (R):** Braconidae

European Honeybee[1] and Bush Bees[2]

Apis mellifera[1] and *Trigona* sp.[2] (Family Apidae)

Description:

European honeybees - are golden-brown in colour with yellow bands on the abdomen and are quite hairy. These bees have a sting. Size: 13–15 mm in length.

Bush bees - are shiny black and have hairy legs on which they carry pollen. These bees do not sting humans. Size: 4–5 mm in length.

Biology and pollinator activity: The life cycle from egg to adult takes about 21 days. European honeybees are similar in appearance to hoverflies. Bush bees look similar to black flies that hover over flowers.

Pollinators are required for fruit set and growers should encourage their presence and breeding. The hive may be some distance from flowering trees. Bees are very sensitive to most insecticides, particularly carbaryl and fipronil.

Bees are more likely to forage in flowers in the early morning. If the weather is cooler, activity may be seen later in the day.

J	F	M	A	M	J	J	A	S	O	N	D

BEES

Above: A bush bee flying onto a flower panicle
Below: European honeybee foraging for nectar and pollen

Fly pollinators

(Family Calliphoridae, Muscidae and Syrphidae)

Description: (adults)

Blowflies (Family Calliphoridae): Many are metallic green or blue with a stout body as well as black bristles on the thorax. Size: up to 8 mm.

Bush flies/house flies (Family Muscidae): Stout grey coloured body with black markings and many bristles. Size: up to 8 mm

Hover flies (Family Syrphidae): Small to medium sized and brightly coloured e.g. with orange and black stripes on the abdomen. Size: 8–12 mm in length.

Biology and pollinator activity: Development from egg to adult is 21–30 days.

Adults are usually seen hovering in the air around flowers. Fly pollinators are very sensitive to most insecticides. Some flowering grasses and flowering shrubs and trees attract pollinators and may be useful when planted between rows or near the orchard.

Flies are often seen pollinating flowers in the early morning, some species may not become active until mid-morning.

J	F	M	A	M	J	J	A	S	O	N	D

FLIES

Above: Blow fly
Below: Hover fly

Flower wasps

(Flower wasps, Family Tiphiidae and
Hairy flower wasps, Family Scoliidae)

Description: (adults)

Flower wasps (Family Tiphiidae): small to large 2–40 mm in length and usually shiny black with brightly coloured yellow markings.

Hairy flower wasps (Family Scoliidae): Usually orange and black in colour and with yellow wings with smokey grey hind margins or all black and with bluish-purple wings and a metallic sheen. They are large hairy wasps up to 40 mm in length.

Biology and pollinator activity:

Flower wasps: These wasps feed on nectar and can be seen flying together between flowers. Most female species are wingless so the male carries the smaller female whilst mating and feeding. In some situations these wasps are important pollinators. Many species also parasitise the larvae of burrowing beetles.

Hairy flower wasps: These wasps feed on flower nectar. Females have spiny legs for digging into wood or soil to look for insect larvae to parasitise.

Wasps are generally seen flying around mango flowers as well as flowering vegetation between rows. Although these wasps are pollinators they are also predatory on various insects.

J	F	M	A	M	J	J	A	S	O	N	D

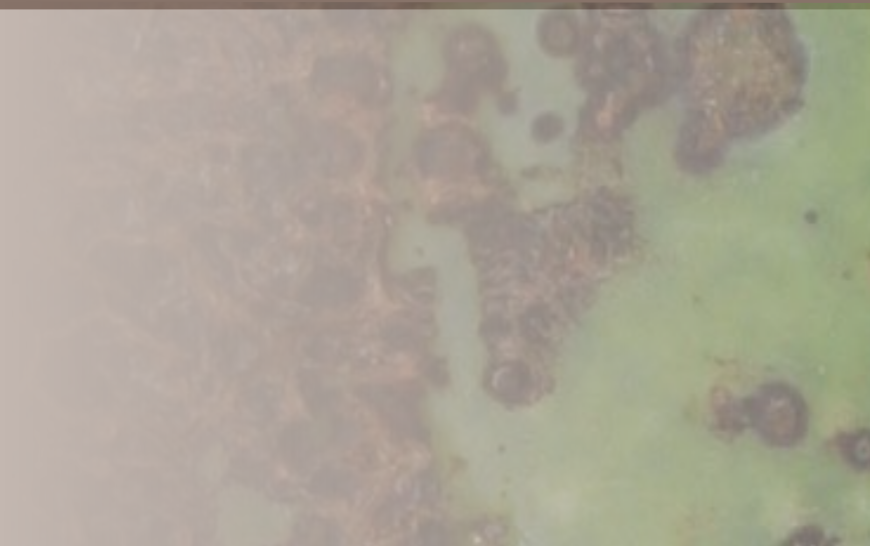
POLLINATORS

WASPS

Above (L): Flower wasps mating **Above (R):** Flower wasp
Below (L): Hairy flower wasp **Below (R):** Hairy flower wasp

MANGO
Field Guide

Diseases



Algal leaf spot

Algal, *Cephaleuros virescens*

Symptoms: Rust-coloured, raised felty spots on leaves, 2–8 mm across, but may coalesce to form larger spots. Older spots become grey and smooth.

Distribution: All mango growing areas.

Favoured by: Poor nutrition, poor growing conditions and other stresses. Dense canopy and wet humid environment. Not common on Kensington Pride.

Similar to: Older damage may resemble chemical toxicity or sunburn.

Control Strategies: Trees should be thinned to improve ventilation and sunshine penetration. Serious outbreaks can be controlled with copper fungicides

Above: Close-up of algal leaf spot colonies
Below: Algal leaf spot on leaves

Anthracnose – General

Fungal, *Colletotrichum gloeosporioides*

Symptoms: These symptoms can occur at different stages of growth, pre- and post-harvest, with a variety of symptoms. Large brown lesions can affect flush leaves or older leaves. Small spots may coalesce into larger lesions. Lesions can occur on twigs and may cause tip dieback. Dark lesions may occur on young fruit or on near-mature green fruit.

Distribution: Common in the Darwin region and as far as Pine Creek; uncommon in the Katherine region.

Favoured by: The disease is more common in areas where there is rain, fog and high humidity in the early dry season. Symptoms are worse in stressed trees.

Similar to: Leaf lesions may be confused with nutritional (calcium) disorders, oedema and thrips damage.

Control Strategies: Strategic fungicide spray application is critical. Timing is influenced by weather conditions. Pruning, orchard hygiene and optimum nutrition, including calcium, can reduce the incidence and severity of anthracnose.

A protective coating of mancozeb or copper should be maintained up to harvest. Two sprays of strobilurin fungicides at flowering and 10 days before harvest is beneficial in reducing anthracnose infection in fruit.

Life Cycle: Dead twigs, branches, flowers and mummified mango fruit are reservoirs of anthracnose infection. Spores germinate in moist conditions and infect fruit within 24 hours.

Above (L): Mango leaf anthracnose
Above (R): Anthracnose lesions on older leaves
Below: Anthracnose on fruit

Anthracnose – Post-harvest

Fungal, *Colletotrichum gloeosporioides*

Symptoms: The latent invisible infection is present in the green fruit in a dormant state, and becomes active during the ripening process. Note that fruit symptoms may not become evident until the fruit arrives at the market. Dark brown to black spreading lesions can occur anywhere on the fruit, but two forms have specific names: tear-stain and stem-end anthracnose. The tear-stain lesions are the result of fungal spores carried down the fruit surface in dew or rain droplets.

Distribution: Common in the Darwin region, less common in Pine Creek and Katherine.

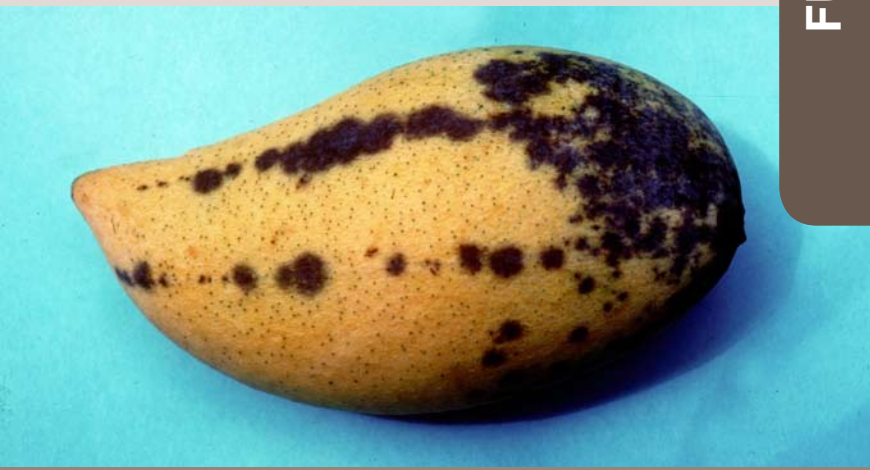
Favoured by: Presence of anthracnose infections in the tree which is a source of spores for latent fruit infections.

Similar to: Post-harvest anthracnose can be confused with other post-harvest rots. Stem end anthracnose can be confused with stem end rots caused by other fungi.

Control Strategies: Suggested post-harvest fruit treatments include fungicide sprays and heat treatments. Pre-harvest management of the orchard, such as pruning, strategic fungicide spray applications, orchard hygiene and optimum nutrition (including calcium) play an important role in reducing the incidence of post-harvest anthracnose. Forced air cooling and maintaining the cool chain at 13–20°C are essential for post-harvest anthracnose control.

Life Cycle: Dead twigs, branches, flowers and mummified mango fruit are reservoirs of anthracnose infection. Spores germinate in moist conditions and infect fruit within 24 hours. There is no evidence of fruit to fruit transmission of the disease after harvest.

Above: Advanced stem-end anthracnose
Below: Tear stain anthracnose



Anthracnose – Pre-harvest fruit symptoms

Fungal, *Colletotrichum gloeosporioides*

Symptoms: Pre-harvest fruit anthracnose is the name given to visible anthracnose symptoms on almost fully developed fruit. Usually anthracnose occurs either as black spots on newly set fruit which drop off, or as a latent infection on larger more advanced fruit. Anthracnose on larger fruit usually remains latent until the fruit ripens, at which time the normal post-harvest fruit symptoms occur. Pre-harvest fruit anthracnose symptoms vary from black spots 1 mm in diameter to circular or irregular spots over 1 cm in diameter. The spots are a glossy black colour with a sharply defined margin and may be slightly depressed below the normal skin surface. If the spots are large, cracks and weeping may occur as the fruit grows. The pre-harvest anthracnose symptom may also be known as pepper spot in some areas of Australia. When the fruit ripens, the pre-harvest fruit anthracnose spots or lesions develop into the normal post-harvest anthracnose.

Distribution: The disease is common in the Darwin region but is less common in Katherine.

Favoured by: Recent observations and investigations indicate that stressed trees (and fruit) are predisposing factors leading to the development of the pre-harvest fruit anthracnose symptoms.

Similar to: Symptoms may be confused with fruit spotting bug damage.

Control Strategies: The best control at present is to ensure that trees (and fruit) are not adversely stressed.

Life Cycle: Dead twigs, branches, flowers and mummified mango fruit are reservoirs of anthracnose infection. Spores germinate in moist conditions and infect fruit within 24 hours.

Above: Pre-harvest anthracnose
Below: Lesions on young immature fruit

Dendritic spot

Fungal

Dendritic spot is thought to be caused by several species of fungi, mainly *Botryosphaeria* spp., and also *Colletotrichum gloeosporioides*.

Lasiodiplodia theobromae is the main fungus associated in Darwin, whilst *Neofusicoccum parvum* (previously *Dothiorella dominicana*) is the main fungus associated with the spot in Queensland.

Importance: The pathogen has recently been recognised as a post harvest disease that is becoming more important, particularly with pressures to obtain fruit earlier in the season as well as an extended season.

Symptoms: Small dark irregularly branched superficial spots appear anywhere on the fruit surface only when the fruit ripens.

Favoured by: Prolonged controlled storage.

Similar to: Dendritic spot is similar to initial symptoms of post harvest anthracnose.

Control Strategies: Since the stem end rot fungi are thought to be involved in dendritic spot, control measures aimed at stem end rot could be useful. These include regular pruning after harvest to remove all dead wood. Fungicides used to control stem end rot may also assist in control.

A ripening mango infected with dendritic spot

Mango Malformation Disease (MMD)

Fungal, *Fusarium mangiferae*, *F. sterilihyphosum* and other species in the *Gibberella fujikuroi* species complex are the cause or associated with the disease.

Symptoms: The most important and damaging symptom on mangoes overseas is the development of malformed or abnormal inflorescences. This is caused by hormonal imbalance associated with the Fusarium infection leading to the development of sterile florets on short internodes and no fruit production. Vegetative symptoms include distorted shoots with shortened internodes, often with a witches broom appearance, and are most common in younger trees.

Distribution: Mango malformation was first recorded from Australia in 2007. In the years since then, MMD has not been a significant disease, with only sporadic occurrences of the symptoms in commercial orchards.

Favoured by: Overseas literature suggests that disease severity is favoured by cooler drier conditions, particularly at flower development.

Similar to: Vegetative symptoms are somewhat similar to mango bud mite. The galling associated with MMD is less developed than that associated with mango bud mite. There is more shoot proliferation with MMD than with mango bud mite damage. Vegetative symptoms of MMD occur in leaf axils, whilst mango bud mite gall symptoms are usually on shoot terminals. Inflorescence MMD superficially resembles symptoms due to the application of excessive quantities of the plant growth regulator, paclobutrazol. However, when the symptoms are due to paclobutrazol rather than MMD, the life of the flowers is not retained for extended periods as with MMD, and normal fruit are produced.

Distorted shoot caused by MMD

Control Strategies: MMD has not developed into an important disease problem requiring control measures. This is possibly because of the warm conditions in northern Australia. In contrast to the situation in other mango growing countries such as India, Pakistan, Egypt and Brazil where it is considered their most important mango disease. In India the disease has been studied for over 100 years and was shown to be more important in the cooler northern areas.

Life Cycle: Infections in new localities are largely due to the movement of mango vegetative material, either as nursery stock or as graft material.

Mango scab

Fungal, *Elsinoë mangiferae*

Symptoms: Small dark brown spots on leaves and young fruits. Leaf margins characteristically distort around spots. Scabs form on fruit spots causing distortion. Raised grey oval to elliptical lesions on stems.

Distribution: More prevalent in the Darwin rural areas. Less significant in the Katherine area.

Favoured by: Rain, fog and high humidity, particularly at flowering and fruit set.

Similar to: Some physical (abrasion) injury, spray or insect injury or lenticel spotting.

Control Strategies: Preventative fungicides (especially copper) used to control anthracnose will inhibit the germination of scab spores, and therefore control mango scab.

Life Cycle: The scab fungus survives in lesions on leaves, petioles and twigs. Spores are formed on these lesions when weather conditions are favourable and are dispersed by wind and rain.

Above: Mango scab on foliage
Below: Mango scab on a fruit

Pink disease

Fungal, *Erythricium salmonicolor*

Symptoms: White to pink paint-like areas on mango trunks especially at branch forks. Pink disease is a rare occurrence in mango trees, but is more common in other crops such as jackfruit and figs.

Distribution: More prevalent in the Darwin rural areas. Pink disease is less significant in the Katherine area.

Favoured by: Rain, fog and high humidity even when produced by spray irrigation. Also favoured by trees which have been unattended.

Control Strategies: Cut out affected branches some distance away from the advancing margins of the visible disease symptoms. Apply copper fungicides. Prune trees to open up the canopy to reduce humidity and render conditions less favourable for fungal infections.

Life Cycle: Not much is known of the life cycle of this disease.

Pink disease on a mango trunk

FUNGAL DISEASES

Sooty blotch

Fungal, an unspecified fungus, possibly *Stomiopeltis sp*.

Symptoms: Sparse superficial dark thread like fungal growth on shoot terminals (stems and leaf petioles), leaves, fruit stalks and sometimes on the fruit. Small dark brown blotches on leaves and young fruits.

Distribution: Most mango growing areas.

Favoured by: Rain, fog, irrigation and high humidity in warm weather.

Similar to: Sooty mould which is easily removed from the plant surface, whilst sooty blotch can not be rubbed off.

Control Strategies: Sooty blotch is usually a minor disease. The fungicides used to control anthracnose may assist in managing sooty blotch.

Life Cycle: Spores are produced after rain from infected tissues, which can start new sooty blotch infections.

Sooty blotch on a stem

Sooty mould

Fungal, various saprophytic mould species.

Symptoms: Abundant dark green-black flaky mould on leaves and stems as superficial growth associated with insect feeding activities. The moulds are not parasitic, but rather saprophytic, growing on the honeydew excreted by some sap sucking insects.

Distribution: Cosmopolitan.

Favoured by: Insect feeding activity.

Similar to: Sooty blotch is somewhat similar. However sooty mould is easily removed from the plant surface, whilst sooty blotch can not be rubbed off easily.

Control Strategies: Sooty mould is managed by controlling the feeding activity of honeydew-producing insects.

Above: Sooty mould on leaves
Below: Sooty mould on the stem end of a fruit

Stem End Rot (SER) – Post harvest

Fungal, mainly *Botryosphaeria* spp.
and some other fungi.

Lasiodiplodia theobromae is the main cause in Darwin, whilst *Neofusicoccum parvum* (previously *Dothiorella dominicana*) is the main cause in Queensland.

Symptoms: The latent infection is present in the green fruit in a dormant state, and becomes active during the ripening process. Note that fruit symptoms may not become evident until the fruit arrives at the market. Symptoms are mostly seen on the stem end of the fruit.

Distribution: It is the major fruit disease in the Katherine area, where there is less anthracnose.

Favoured by: Water stressed plants and immature fruit. The infection occurs pre-harvest and then lies dormant until ripening begins. SER is more prevalent in older orchards.

Similar to: SER can be confused with post-harvest rots caused by other fungi, particularly stem end anthracnose.

Control Strategies: Pre-harvest management of the orchard, such as pruning to remove dead (infected) tissue allows a more effective spray coverage. Orchard hygiene and optimum nutrition play an important role in reducing the incidence of SER. Avoid harvesting immature fruit. Post-harvest management includes hot water and fungicide treatments. Forced air cooling and maintaining the cool chain at 13–20°C are essential for post-harvest disease control. Two sprays of the strobilurin fungicides at flowering and 10 days before harvest is beneficial in reducing SER infection in fruit.

Life Cycle: SER fungi are endophytic within branches. They grow into the fruit stalks at flowering and enter the fruit as it is developing.

Stem end rot in a ripe fruit

Stigmina leaf spot

Fungal, *Cercospora mangiferae*

Symptoms: Small circular to angular black leaf spots 1–2 mm in diameter, often coalescing to form larger angular spots. The spots are surrounded by a distinctive yellow halo. Stigmina leaf spot is characterised by its ready sporulation on the lower leaf surface in wet weather or when samples are moist incubated. Restricted to leaves.

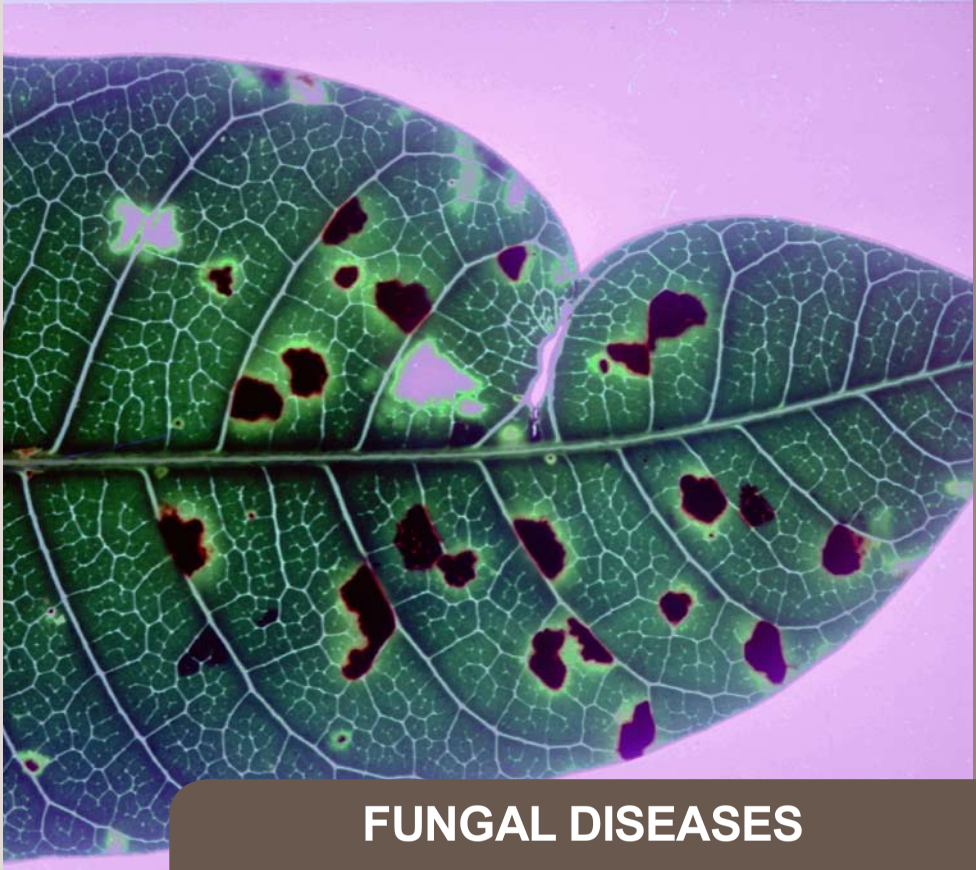
Distribution: More prevalent in the Darwin rural areas, where it is more humid. Less significant in the Katherine area.

Favoured by: Rain, fog and high humidity.

Similar to: The symptoms are similar to bacterial black spot which affects the leaf stalks, stems, buds and fruit but tends to have a more glossy margin than stigmina leaf spot.

Control Strategies: Stigmina leaf spot does not warrant control measures.

Life Cycle: Spores are formed on these lesions when weather conditions are wet and humid and are dispersed by wind and rain to start new infections.



Stigmina leaf spot

FUNGAL DISEASES

Bacterial black spot

Bacterial, *Xanthomonas campestris* pv. *mangiferae-indicae*

Symptoms: Leaf spots are black, raised and angular with or without a yellow halo. Twig and stem lesions are black and cracked. Tip dieback may occur. Black scabby spots with star-shaped cracks appear on the fruit.

Distribution: Darwin to Katherine.

Favoured by: Unseasonable wet conditions during fruit development.

Similar to: May be confused with stigmina leaf spot.

Control Strategies: Pruning off affected stem cankers on seedlings and budwood can help manage bacterial black spot. Copper sprays are beneficial if the disease is severe.

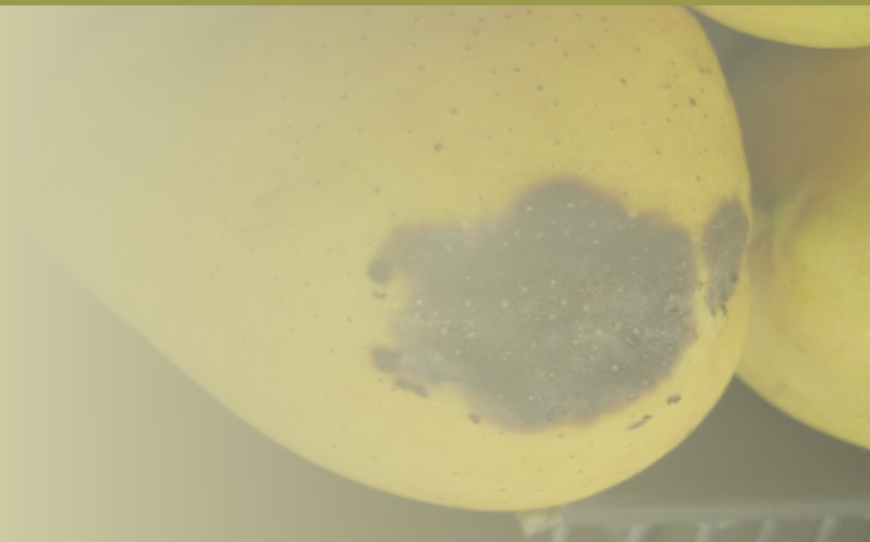
Life cycle: The bacteria harbour in stem cankers on seedlings and on budwood. These sites can act as reservoirs from which the disease can spread to leaves and fruit when conditions are favourable.

Bacterial black spot

BACTERIAL DISEASES

MANGO
Field Guide

Disorders



Boron deficiency

Nutritional Disorder

Importance: Boron is important in pollination, fruit set and calcium uptake.

Symptoms: Emerging leaves are lop-sided with ragged edges. Leaves can have a shot-hole effect. In extreme cases, bark cracking and weeping occurs. Some varieties such as the Thai variety Keow Savoey are particularly prone to boron deficiency.

Similar to: Can be confused with anthracnose or mango scab on young leaves.

Distribution: Found in both the Darwin and Katherine regions.

Control Strategies: Monitor the levels of boron in soil and in leaves, and correct deficiencies as recommended.

Caution: Do not apply excessive rates of boron as this can be toxic to plants.

Above: Weeping sap 'gumming' on the trunk
Below: Leaves with black tips and margins

Boron toxicity

Nutritional Disorder

Importance: Boron toxicity can severely affect the current year's production.

Symptoms: Usually on older leaves causing leaves to have brown edges and a distinctive scalloped pattern. Some yellowing occurs between the veins on the leaves. Older leaves turn bright yellow with scalloped brown edges and stay attached to the tree.

Distribution: Found in all mango growing areas. This condition is almost always caused by the application of excessive amounts of boron fertilisers.

Favoured by: Low pH soils and elevated water tables.

Control Strategies: Excess boron becomes fixed in the older leaves and will eventually return to normal levels. A regular series of soil tests for nutrition or following the correct recommended rate, in relation to the size of the trees, will help to avoid this problem.

Boron toxicity symptoms on leaves showing distinctive scalloped pattern

Lime toxicity

Nutritional Disorder

Importance: Lime toxicity occurs in areas that have high limestone deposits. Plants affected will gradually die.

Symptoms: Dieback is noticed, particularly on young trees.

Cause: The high pH due to the calcium in the lime, renders many minerals unavailable to the plant. Smaller plants die first as mineral reserves in the plant are depleted.

Distribution: All mango growing areas, especially the Katherine area.

Favoured by: High limestone deposits.

Treatment: Avoid planting trees in the proximity of limestone.

Lime toxicity affecting a young tree

Zinc deficiency

Nutritional Disorder

Importance: Zinc is important for the proper functioning of the tree and is critical for fruit retention. Trees with chronic zinc deficiency have poor growth and low yield.

Symptoms: Usually seen on new growth. Symptoms include smaller leaves or pale yellowish-brown coloured or curved puckered sections between the veins.

Distribution: This disorder is more common in the Darwin region.

Favoured by: High soil pH, high rainfall and excessive tree vigour. The warm tropical climate in Darwin is very conducive for zinc deficiency. Vigorous shoot growth after pruning can induce zinc deficiency.

Control Strategies: Monitor soil and leaf levels and follow soil and foliar applications as recommended. Soil applications should be applied in the wet season and foliar sprays to the soft leaf flush.

Zinc deficiency in mature leaves showing curved puckering between veins

Fruit splitting

Physiological Disorder

Importance: Fruits with splits are unmarketable.

Symptoms: Rapidly growing fruit crack and split. The split becomes brown and dried out, sap may ooze from the split.

Causes: It is believed that significant fluctuations in soil moisture levels and atmospheric humidity during rapid growth of fruit is responsible for fruit splitting.

Control Strategies: Irrigation management and maintaining stable moisture levels during fruit development. Use soil moisture monitoring devices like tensiometers.

Above: Vertical splitting
Below: Horizontal splitting

Jelly seed

Physiological Disorder

Importance: Jelly seed downgrades the fruit quality.

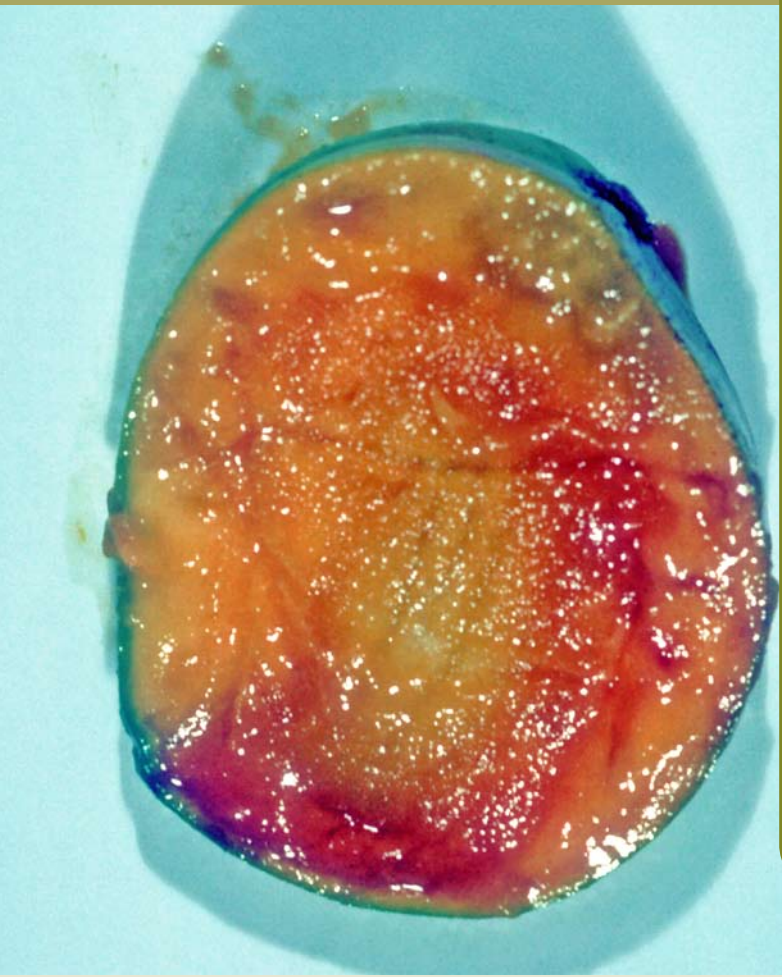
Symptoms: Fruit with jelly seed have over-ripe flesh around the seed when the rest of the flesh is just beginning to soften. The over-ripe flesh around the seed decays prematurely with off odours and flavours. The flesh at the stem end is fibrous.

Distribution: Most mango growing areas. This condition is more common in South East Queensland.

Favoured by: Certain varieties such as Tommy Atkins, Zill and Sensation are susceptible to jelly seed, but it is rare in Kensington Pride.

Similar to: The disorder may be confused with other physiological conditions such as soft nose and internal breakdown, a condition to which Keitt is particularly susceptible.

Control Strategies: Avoid growing varieties which are prone to jelly seed in your area.



Fruit with over-ripe, jelly-like flesh around the seed

Oedema

Physiological Disorder

Importance: May indicate unfavourable growing conditions.

Symptoms: Numerous raised areas on the underside of the leaf, usually about 1–3 mm diameter. The swellings are initially water-soaked in appearance, later tending to be brownish or black. Oedema results from water retention in the tissues.

Favoured by: Wet conditions, high humidity, high rainfall and over-irrigation. Other stresses such as poor nutrition and sunburn can alter the physiology of the plant and predispose the tree to oedema.

Distribution: Wherever natural or artificial conditions are conducive.

Similar to: May be confused with redbanded thrips damage.

Control Strategies: If possible, avoid over-watering or uneven watering throughout the year. Consider whether other stress factors may be operating and correct these if possible.

Above: Early stage oedema
Below: Advanced oedema

Prominent lenticels

Physiological Disorder

Importance: Prominent lenticels may downgrade the fruit quality.

Symptoms: Prominent brown coloured lenticels. This condition is also known as lenticel spot or lenticel spotting. The corky tissue in the lenticels swell and darken causing the fruit to have a spotted appearance. This is more obvious as the fruit colour becomes yellow with ripening.

Distribution: Occurs in all mango growing areas of Australia.

Favoured by: Lenticel spotting has been associated with excessive time in water dips and excessive detergent in water washes, although the true cause of the disorder has not been fully determined.

Similar to: Prominent lenticels can be confused with very early symptoms of mango scab.

Control Strategies: Avoid excessive amounts of detergents and excessive post harvest dipping time.

Prominent lenticels on mature green fruit

PHYSIOLOGICAL DISORDERS

Resin canal

Physiological Disorder

Importance: Generally noticed when the fruit mature and is thought to be caused by stress. Fruit is downgraded.

Symptoms: Prominent brown coloured resin canals or threads from the skin through the flesh.

Distribution: Occurs in all mango growing areas of Australia.

Favoured by: The symptoms are more common in fruit towards the end of the mango season. The condition has been noticed in stressed fruit.

Similar to: The symptoms may be confused with dendritic spot. However, dendritic spot is superficial and does not have coloured threads running from the skin and into the flesh.

Control Strategies: At present, very little is known about the causes of resin canal and what can be done to prevent it.

Above: Resin canal symtoms on mature fruit
Below: Resin canal symtoms in fruit flesh

Stem end cavity

Physiological Disorder

Importance: Affected fruit are unmarketable.

Symptoms: Externally, in severe cases the fruit develops a grey-brown sunken area near the fruit stalk. Affected fruit suffer premature ripening and are prone to extensive wind drop. External symptoms are not always evident.

The vascular fibres that connect the mango stem to the flesh and top of the seed snap or tear forming a cavity lined with fibres at the stem end. This results in a breaking of sap pressure and premature ripening of the fruit flesh around the tear and seed.

Favoured by: This disorder is favoured by certain cultivars, high leaf nitrogen, low calcium leaf levels, wet windy conditions and harvesting fruit that have been allowed to fully ripen on the tree. The Kensington Pride variety is particularly prone to stem end cavity.

Similar to: Stem end cavity may be confused with some symptoms of jelly seed.

Control Strategies: The best methods to reduce the incidence of the disorder include early harvesting and discarding of all fruit that fail to bleed or exude sap in the de-sapping operation.

Above: External symptoms showing a depressed grey/brown area towards stem end
Below: Internal symptoms showing a cavity lined with fibres

Sunburn

Physiological Disorder

Importance: Sunburnt fruit is unmarketable. Sunburnt trees can develop secondary infections from borers and fungal diseases.

Symptoms:

Sunburnt fruit - appears discoloured with cracked skin followed by necrosis. Lop-sided flat fruits occur mostly on the western aspect of the tree.

Sunburnt branches - may occur after heavy pruning and exposure to the sun. The lifting and cracking of the bark may lead to insect and fungal attack, and sometimes death. Leaves on affected branches show oedema symptoms.

Control Strategies: Planting trees in an east-west row orientation may help to avoid or minimise the problem. Follow correct pruning techniques. Maintain good nutrition and irrigation practices. If heavy pruning is required, protect exposed branches with a diluted water-based white paint. Some growers use kaolin clay-based spray as a sun protectant. Do not leave harvested fruit in the sun.

Acute sunburn on fruit shoulder

PHYSIOLOGICAL DISORDERS

Herbicide damage

Other Disorder

Importance: Herbicides can severely damage or kill young mango trees or low branches on mature trees.

Symptoms: Application of herbicide within the spray zone or drift can cause the following symptoms. Contact herbicides such as paraquat can cause leaf burn. Systemic herbicides such as glyphosate can cause narrow, chlorotic, elongated, curled and distorted leaves. Often symptoms are seen at the ends of rows. Application with the wrong dosage can kill young trees.

Control Strategies: Alternatives such as mulching can be used around the base of young trees to reduce the growth of weeds. Appropriate spray technology is recommended. Do not spray in windy conditions. Prevent spray drift to green parts of the tree including the stem in young trees. Prune low hanging branches so that they are not within the herbicide spray zone.

Above: Narrow-elongated leaves caused by systemic herbicide
Below: Distorted mango shoot affected by hormonal herbicide damage

Fruit blemishes

Other Disorder

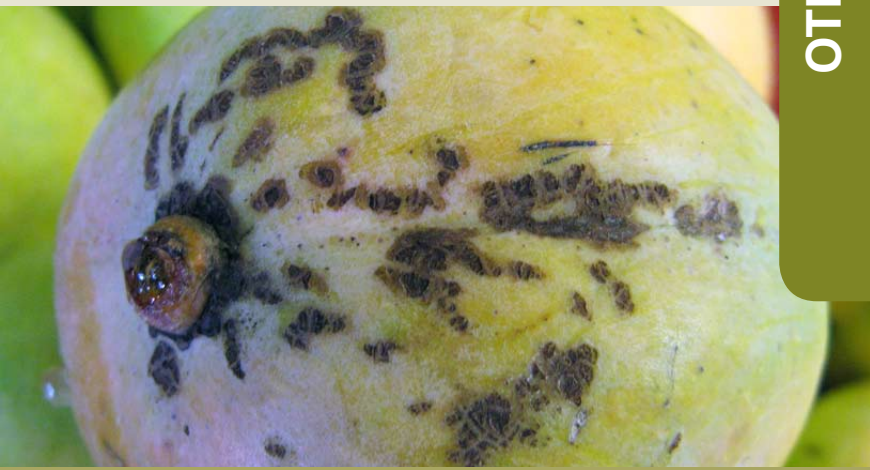
Importance: Blemish downgrades the fruit quality.

Symptoms: A wide range of scratches and marks on the fruit.

Causes: Wind or rubbing from adjacent plant parts or scratching and feeding damage by birds, bats or possums. Green ants may spray formic acid (defense mechanism) which causes black spots on fruit.

Control Strategies: Proper pruning techniques will minimise fruit marking. Some growers prune shoots and other plant parts which are likely to cause rub marks. Good nutrition levels, especially calcium, will impart hardiness to fruit.

Above (L): Wind abrasion
Above (R): Black spots caused by formic acid from green ants
Below: Abrasion near the stem end of fruit



Inflorescence tip dieback

Associated with *Cladosporium* sp. and other fungi

Importance: Can be severe in some seasons and cause significant loss of flowers.

Symptoms: Necrosis and shrivelling of parts of the inflorescence, particularly the tip. There may be grey-green or brownish mould growth of the fungus *Cladosporium* which is not a pathogen, but a saprophyte that colonises recently dead mango tissue.

Favoured by: Harsh conditions e.g. drying winds lead to death of the delicate tissue. Factors which lead to poor pollination may contribute to the condition.

Distribution: Wherever conditions are conducive.

Similar to: Symptoms may resemble those of powdery mildew which is a problem in Queensland but not in the Northern Territory.

Control Strategies: From flowering to early fruit set ensure optimum conditions for flowering and fruiting.

Above: Early stage of inflorescence tip dieback
Below: Irwin inflorescence showing tip dieback

Lightning injury

Other Disorder

Importance: Lightning may cause injury or the death of trees and subsequent gaps in the orchard.

Symptoms: Trees are affected in groups, but not necessarily adjacent to each other. Most trees are usually affected from indirect strikes where the lightning travels from the ground and upwards through the trees. Often the bark cracks and dries out. Sometimes there is a line of dead bark tissue leading from the ground towards the terminal branches. There may be brown internal discoloration and an exudation of gum. Affected tissue may have an unusual cooked smell. Fruit may appear cooked. The surviving trees are more susceptible to insects (such as longicorn beetle) and secondary wood rot fungi.

Favoured by: Prevalent in the Top End of the Northern Territory. Areas with underlying laterite seem especially prone to lightning strike.

Distribution: Potentially in all mango growing areas where lightning occurs.

Similar to: Damage to the tips of shoots with dead or dried leaves may be confused with redbanded thrips damage or longicorn damage.

Control Strategies: Trees affected by lightning will be weakened and may deteriorate over a few months and usually do not recover.

Above (L): A young tree affected by lightning strike
Above (R): Mango branch showing cracks in the bark from lightning strike
Below: Extreme shock caused by lightning may cause leaf drop

Phytotoxicity

Other Disorder

Importance: Foliage may be damaged and fruit may be unmarketable.

Symptoms: Dark or black raised lines on the surface of leaves and fruit, often appearing as a network of lines on fruit. Copper fungicides are a common cause of phytotoxicity. It is mostly associated with the addition of other chemicals or surfactants that are not recomended for mixing with copper products.

Distribution: Phytotoxicity can occur anywhere within the mango growing regions.

Favoured by: Occurs when copper sprays (copper oxychloride or copper hydroxide) are applied with or shortly before or after sprays of zinc sulphate or certain incompatible chemicals, especially surfactants.

Similar to: Some types of blemishes, and some forms of mango scab.

Control Strategies: Copper fungicides should not be sprayed with, or shortly before or after sprays of zinc and other incompatible chemicals.

Above: Copper spray damage on leaves
Below: Copper damage on fruit

Pre-harvest sapburn

Other Disorder

Importance: Severe sapburn makes the fruit unmarketable. Low level sapburn makes the fruit more susceptible to disease infection.

Symptoms: Often pre-harvest sapburn is caused by planthoppers feeding on the fruit stalk. If planthoppers are present on the fruit, sometimes sooty mould can be seen near the sapburn. Sapburn can also be caused by physical damage.

Distribution: Widespread in mango growing areas.

Favoured by: High insect loads, high winds and storms.

Treatment: Effective insect control and correct pruning techniques. Regular fungicide sprays may reduce the risk of infection from anthracnose in areas where the skin has been damaged.

Above: Local sapburn
Below: Streaking sapburn

Procedure for monitoring pests and natural enemies in mango orchards.

1) Divide the orchard into blocks of 100 trees.
2) Monitoring is especially important prior to flowering and during the flowering and fruiting periods. Monitor 10 trees per 100 trees (10 per Ha) at weekly intervals or every 2–3 days during flowering as caterpillars can cause extensive damage in a short time. For orchards with more than 500 trees, set aside at least 1–2 hours per week for monitoring.
3) Individual trees selected for monitoring are chosen at random, ensuring that a reasonable coverage has been made of the fruit trees on the edges and within the orchard.
4) Suggested sampling technique for each randomly selected tree:
   - most insects are found on the flush, flowers and fruit rather than old shoots
   - focus the general sampling area on the new shoots, flower panicles or fruit unless you are inspecting the tree for borers or termites
   - sample 4 points per tree N, S, W, E
   - it is easier to sample at head height, however, be aware of pests that are on foliage lower and higher than head height.
5) Record information as shown on a monitoring sheet or note book.
6) The insect action level is the pest population density at which control is recommended. Refer to insect action levels.

Action Level

Insect action levels for the Northern Territory

The action level is the pest population density at which control is recommended.

To determine insect action levels, survey 10–20 trees per hectare (or 10–20 trees per 100 trees). Refer to the Orchard monitoring procedures on previous page.

Insect	Examine	Action levels and comments
Mango leafhopper	Examine flower panicles or in the months leading up to flowering, examine new terminal shoots.	Control if there is 1 or more per orchard. In low populations only spray affected trees.
Mango Planthopper	Terminals and fruit stalks.	Control if 10% of terminals or fruit stalks are infested.
Redbanded thrips	Leaves	Control if 10% of terminals are infested.
Dimpling bug	Examine flower panicles.	Apply treatment when there are 2 or more bugs per 4 trees.
Flower eating caterpillars	Examine flowers, pull apart webbing look for live caterpillars.	Control when there are 2 or more per flower panicle.
Mango scale	4–5 terminals per tree. Look for live females and crawlers.	Immature females and crawlers are the easiest to control. Mature females are difficult to control. Control when susceptible before flowering and harvest.

Mango tip borer	Terminals	Control if 10% of terminals are infested.
Mango seed weevil	Examine golf ball size fruit for egg laying blemishes with leaking sap.	Control if there are egg laying blemishes on fruit on more than 2 trees per 100 trees. When exporting fruit refer to Quarantine requirements .
Fruit spotting bug and tea mosquito bug	Examine new shoots and small fruit for bugs and damage.	Control when there is fresh feeding damage or 1-2 bugs per tree. Spot spray affected trees and nearby trees.
Fruit flies	Monitor with CUE lure traps to get an idea of population. Traps only capture male fruit flies.	Control as per ICA requirements.
Longicorn beetle	Check for dying shoots (yellowing leaves) or branches.	Treat all trees affected. Prune and destroy affected branches. Sprays may assist control.
Giant termite	To detect giant termite activity drill a hole approximately 12 mm diameter into the centre of the trunk at waist height. If termites are active they will seal this hole with mud on the outside after 24 hours. Ring barking, termite mud on trunk and branches and folded hollow branches are also indications of termite activity.	Trees can be treated by trunk injection or soil injection. Alternatively, termites can be aggregated in aggregation drums and treated once highly active (up to six weeks). Please contact the Department of Resources (for NT growers only) for details of termiticides.
Mango fruit borer	Look for holes and extruded frass (insect droppings) on developing fruit, including fallen fruit.	In the NT, please report any caterpillars boring in mango fruit to the Department of Resources, Entomology on 08 8999 2259.

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Mango variety: R2E2. www2.dpi.qld.gov.au/horticulture/5443.html

Glossary

A	abdomen	the rear body segment of an insect or arthropod
	antennae	sensory appendage occurring in pairs on the head of insects and most other arthropods
	arthropod	an invertebrate that has a segmented body, jointed limbs and usually an exoskeleton that undergoes moultings (examples include: insects, spiders, mites and others)
B	*Bacillus thuringiensis*	a biological insecticide (e.g. for control of caterpillars)
	bristles	short, stiff, coarse hair
C	canker	a localised dry dead area on stem or other plant part
	cephalothorax	fused head and thorax of a spider
	chelicerae	pincer-like first appendage of spiders
	chlorosis	partial or complete absence of green colour in plant part
	coalesce	merge by growing into each other
	cosmopolitan	occuring throughout the world
	crawlers	young mobile stages of scales, mealybugs and fluted scales
D	dendritic	of a branching form
	dieback	death of tissue starting from the tip and progressing downwards
	disorder	harmful deviation from normal function, not caused by a pathogen

E	elongate	longer than wide
	endophytic	living or feeding within plant tissue
	epidermis	skin of plant
	excreta	faecal matter
	exoskeleton	external covering or skeleton of an arthropod
	exudate	secretion
F	frass	insect excrement that may include, silk, sawdust or chewed plant material
	flush	newly developed leaves
G	gall	localised proliferation of plant tissue
H	honeydew	sugary substance excreted by some sap-sucking insects
	hot spots	trees within orchards where insects aggregate
I	innoculum	unit of the pathogen that is capable of initiating a new infection
	instar	a stage in an immature insect's life cycle
	internode	a segment of a plant stem between two successive nodes
	invertebrate	an animal without a backbone
L	larva (plural larvae)	immature stage of an insect (often grub-like) (occurs in complete metamorphosis)
	lesion	injury or wound
	latent	present but not apparent
	lenticel	small pore on a stem or other plant part

Glossary

M	mandibles	first pair of jaws in insects
	mid-rib	main vein on leaf
	monitor	to detect/examine and record
	moult	to shed skin
	metamorphosis	the change in form from one stage to the next in the life history of an insect or organism
N	necrosis	death of tissue
	nocturnal	active at night
	node	refers to a leaf node which is the point on a stem where a leaf is attached or has been attached
	nymph	immature stage of an insect, which usually resembles the adult but does not have wings (occurs in incomplete metamorphosis)
O	oedema	localised blister-like swellings usually on leaves
	ootheca	collection of eggs
	oviposit	deposit or lay eggs
P	palps	segmented appendages found near the mouth
	panicle	branching flower cluster
	parasite	an organism which feeds on, or in another organism
	pathogen	an organism or agent (e.g. fungus or bacterium) capable of causing disease in a host
	peduncle	fruit stalk

P	petiole	leaf stalk
	photosynthesis	in plants, the synthesis of carbon dioxide, water and inorganic salts, using sunlight
	polyphagous	feeds on many different types of plants
	predator	an animal naturally preying on other organisms
	pupa (plural pupae)	the inactive stage between larva and adult (in complete metamorphosis)
	pupate	to turn into a pupa (occurs between the larval and adult stage)
R	ringbark	remove a band of bark around the trunk, branch or stem
	russeting	a reddish brown roughened area on the skin of fruit caused by injury
S	saprophyte	an organism which uses dead organic material for food
	skeletonise	chewing damage on leaves (usually caused by beetles), reduced to a network of veins or framework of the leaf
	spore	a one- to many-celled microscopic body produced by an organism which is capable of growing into a new organism
	sooty mould	black fungus generally growing on honeydew
T	thorax	the body part between the head and abdomen that the legs and wings are attached
	tissue	a group of cells that perform similar or related functions

Index

This index contains, common and scientific names of pests, beneficials, diseases and disorders of mangoes.

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FIELD GUIDE

to Pests, Beneficials, Diseases and Disorders of Mangoes

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