Biodiversity and agriculture: addressing scale insect threats in Kenya

# SCALE INSECT FACT SHEETS

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# FACTSHEETS FOR FARMERS
## Kenya


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# Introduction

## What are Scale Insects?

Scale insects are a group of sap-sucking insects that insert their tiny, straw like mouthparts into the bark, fruit, or leaves, mostly on trees and shrubs and other perennial plants. Adult females typically have soft bodies and sometimes no limbs and may be concealed underneath domed scales, extruding quantities of wax for protection. The presence of scales can be easily overlooked, in part because they do not resemble most other insects and are easily mistaken for a disease or symptoms. Scale insects are broken into three major distinct groups i.e. ***Coccidae*** (soft scales); ***Diaspididae*** (armoured scales); and ***Pseudococcidae*** (mealybugs)

On Kenyan farms, most scales are serious pests of agriculture and forestry. They attack a wide range of plant species including crops of economic importance in Kenya e.g. coffee, citrus, mango, avocado, sugarcane, pawpaw, cassava etc. Scales and mealybugs cause direct damage by removing a lot of water and biomass from the plant. The toxic saliva injected into the plant by some scales can damage plant tissues, sometimes killing the plant. Some scales have been reported to transmit plant viruses e.g. Citrus mealybug (***Planococcus citri***), Pink sugarcane mealybug (***Saccharicoccus sacchari***), Striped mealybug, ***Ferrisia virgata***; cause dieback e.g. the hemispherical scale (***Saissetia coffeae***) on coffee; or cause black spots e.g. the pineapple mealybug (***Dysmicoccus brevipes***) etc.

Some scale insects (soft scales and mealybugs) eliminate sugary honeydew which coats nearby surfaces, e.g. Papaya mealybug (***Paracoccus marginatus***). Black sooty mould grows on the honeydew, disfiguring the plant and produce, so reducing crop yield and its commercial value. Sooty mould also blocks light and air from the leaves, impeding gas exchange and photosynthesis, further reducing productivity.

Scales are difficult to control as the waxy covering protects them effectively from contact insecticides. Their sugary honeydew waste attracts attendant ants which protect them from activities of natural enemies and aid in their spread. This exacerbates the pest problem. It is for this reason that biocontrol is proposed as the best alternative to insecticides in the management of scale insects and mealybugs.

This photo booklet aims to aid farmers, foresters and extension personnel to correctly diagnose scale insects present in Kenya to inform action. The pest species are covered in the three distinct groups (soft scales, armoured scales, mealybugs and other scales); for each pest, a brief description of the morphology, ecology and host species attacked is given.

# Contents

# Red scale, *Aonidiella aurantii*

## Recognise the problem

*Aonidiella aurantii* probably originated in South China, but has been dispersed widely by human transport of infested plant material. It attacks host-plants in 178 genera belonging to 84 families, but is mainly known as an important pest of citrus. Other crops attacked include avocado, mango, coconut, papaya, guava, passion fruit, pomegranate, okra etc. The scale is a major threat to citrus production throughout the world, attacking all above-ground parts of the trees. On young trees it attacks the trunks, forming thick incrustations, and infests the leaves and fruit also. The insects on the leaves suck out cell contents and inject toxic saliva, which causes them to turn yellow and drop. The scale does not produce honeydew or cause sooty mould. Heavy defoliation stunts tree growth and affects the yield. Heavy infestation especially on fruits, which are difficult to remove even by descaling machines, reduce their market value. Generally, neglected infestations lower the productivity of an orchard. On other fruits, infestation may cause discolouration. On older rose bushes, attack causes dieback, debilitation and even death.

*Aonidiella aurantii* on citrus leaf (Photo: James Bailey/Bugguide.net)

Citrus fruit damage by *A. aurantii* (Photo: Candidegardening.com)

## Background

Adult female *A. aurantii* are brownish or orange-red and oval to circular and about 1.5-2.0 mm long; beneath the scale cover the adult female becomes kidney-shaped at maturity. The female produces a sex pheromone to attract the short-lived, winged males; she later gives birth to first-instar crawlers. The crawler is the main dispersal stage of red scale; it can walk short distances, but can be distributed passively across much greater distances by wind and flying insects and birds, so infestations spread down the direction of the prevailing wind. Human transport of infested plant material can carry the scale over long distances. The development rate depends on environmental conditions, especially temperature and light. After harvest, *A. aurantii* overwinters on twigs and leaves where it is able to infest new growth, beginning another cycle. It is therefore important to remove plant residues that could harbour them during this period. The sex pheromone of *A. aurantii* has been synthesized and can be used in sticky traps for monitoring the population size.

## Management

- Avoid movement of infested plants between locations, farms and regions.
- Carefully inspect planting material; reject and destroy any infested plants.
- Observe proper plant spacing to avoid plants touching each other, and prune trees to prevent their canopies touching – this helps to limit scale insect spread between trees.
- Scout the orchard regularly to detect the presence of the scales early.
- Prune off infested plant parts; remove and destroy them by burning or burying 50 cm deep.
- Clean pruning equipment thoroughly before moving to another plant.
- Conserve natural enemies like ladybirds – avoid or minimise chemical spraying, dust etc and maintain crop/plant diversity within the farm. Control ants in the trees, as they attack the natural enemies of scales and can interfere with biological control. Biological control using parasitoid wasps is very successful against red scale in South Africa.
- If necessary, spot treat affected trees as opposed to the whole tree/farm.
- Use soap solution or botanical pesticides like neem extract, or commercial horticultural oil emulsion, that have low impacts on natural enemies, the environment and human health.
- In large-scale commercial orchards, synthetic pheromone can be used to disrupt red scale mating and to bait sticky traps to monitor scale numbers.
- Implement an integrated approach against this pest by combining cultural, biological, physical and (only as a last resort) synthetic pesticides.
- Only as a last resort, spot-treat infestations with a narrow-spectrum pesticide.

# White scale of sugarcane, *Aulacaspis tegalensis*

## Recognise the problem

*Aulacaspis tegalensis* is a tropical species indigenous to the islands of South-East Asia and West Malaysia; it was accidentally introduced to East Africa on imported sugarcane seed canes/setts. It has a restricted host range on grasses and can thrive on cultivated sugarcane. *Aulacaspis tegalensis* is essentially a stem-feeder, aggregating in the nodal regions inside the leaf sheaths, and is only found on leaves as a result of secondary infestation or overcrowding on the stem. Large injurious populations are only possible when the stems are well developed. The nymphs and adult females suck out cell contents and inject toxic saliva; the scales do not produce honeydew or cause sooty mould growth. Saliva toxicity causes chlorotic spots and necrotic lesions on the leaves. Heavy infestation by *A. tegalensis* results in reduction or loss of yield, a decrease in the sap sucrose content and a reduction in the purity of the sugar; also, the cost of replanting damaged fields increases production costs. Low sucrose content makes sucrose extraction more difficult and therefore costlier. Persistent heavy infestation can lead to decay and death of canes. Another, similar *Aulacaspis* species that attacks sugarcane in East Africa is *Aulacaspis madiunensis*, whose female scale cover is only slightly convex and has yellow-brown submarginal or marginal exuviae. The two species often occur in mixed colonies on sugarcane.

Symptoms of *A. tegalensis* attack on sugarcane (Photo: IPM, Bogor Agricultural University)

*Aulacaspis tegalensis* on sugarcane crop,Uganda (Photo: David J. Greathead)

## Background

*Aulacaspis tegalensis* is normally found on mature stems inside the leaf sheaths; this species does not thrive on other parts of sugarcane. The female scale covers are subcircular, convex, thin, greyish white, with yellow cast skins at the margin; immature male covers are white, elongate oval with 3 longitudinal ridges, and much smaller than those of the female. Reproduction is sexual; each female can lay 700-800 eggs and on heavily infested sugarcane, crawlers are produced by the millions. Crawlers prefer to aggregate in the nodal regions and in heavy infestations the massed scales form crusts on sugarcane stems. The first-instar crawlers are responsible for dispersal but cannot walk far and normally settle near the parent scale, usually on the shoot on which they hatched; however they can be carried passively by ants, birds and wind. The behaviour of crawlers is affected by temperature, humidity and sunshine; dry, bright conditions favour the aerial dispersal of crawlers and lead to an increase in the population. Long-distance dispersal is by agricultural practices and movement of infested seed cane.

## Management

- Practice crop rotation with non-grass crops to prevent pest carry-over between one sugarcane crop and the next.
- Practice good field hygiene – remove leftover cane roots and shoots after harvest to prevent pest carry-over between one sugarcane planting and the next.
- Remove weeds (especially grasses) from the field before planting, to prevent pest carry-over.
- Exploit host-plant resistance: tight-threshing sugarcane varieties are more prone to scale attack, so select a variety that is resistant to attack before planting.
- Use clean planting material. Inspect and destroy any scales found on the cuttings/stalks before planting.
- Clean equipment carefully before moving from one infested field to the next.
- Conserve natural enemies like ladybirds and parasitic wasps – avoid or minimise broad spectrum insecticide spraying, reduce dust, maintain crop diversity etc.

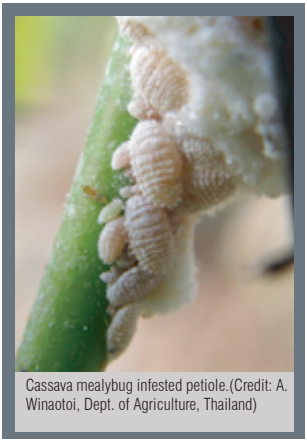
## Cassava mealybug, *Phenacoccus manihoti*

### Recognise the problem

Cassava mealybug is one of the most severe pests of cassava (*Manihot esculenta*). It is native to South America and achieved pest status after accidental introduction to Africa. The rapid spread devastated cassava production, causing yield losses of sometimes over 80%, greatly threatening food security. Damage is caused as a result of mealybugs sucking sap from plant tissues and injecting toxic saliva, stunting and distorting growth so the leaves clump together into "bunchy tops" and stem growth is stunted and distorted; leaves dry up and, if the attack is severe, considerable defoliation can result. Damage is most severe in the dry season. As the mealybugs feed, sugary honeydew is expelled, fouling plant surfaces and providing a medium for the development of sooty mould. The mould covers leaves, imparing the exchange of gases and photosynthesis, reducing plant growth and root quality. Ants tend mealybugs for their sweet honeydew, and protect them from attack by parasites and predators. Sometimes attendant ants help to spread the mealybugs.

Cassava mealybug, distorting terminal shoot of cassava - "bunchy top" (Credits: Pestnet.org).

Adults and nymphs of the cassava mealybug (Credits: Georg Goergen, International Institute of Tropical Agriculture (IITA), Insect Museum, Cotonou, Benin).



Cassava mealybug infested petiole.(Credit: A. Winaotoi, Dept. of Agriculture, Thailand)

### Background

Infestations are common on shoot tips, leaf undersides and stems, and form large amounts of white waxy secretions. The females are wingless, oval, pinkish, and have very short marginal wax filaments. Cassava mealybugs reproduce without mating/fertilisation (they are parthenogenic), so a single female may be sufficient to start an outbreak. Dispersal over short distances is by crawlers walking; or over longer distances when they are carried by wind currents, vehicles, animals, birds, on clothing, or during exchanges or distributions of cuttings. Rainfall suppresses *P. manihoti* numbers mainly by causing mechanical mortality, but also by favouring insect pathogens and reducing cassava's suitability as a host.

### Management

- Host-plant resistance - select varieties that are resistant to cassava mealybug.
- Avoid the movement of planting material (cuttings) from infested areas to other areas - institute strict domestic quarantine measures between counties.
- Use clean planting material (cuttings) — de-infest cuttings before planting.
- Practice crop rotation with crop species outside the cassava family (Euphorbiaceae).
- Monitor / scout regularly, for early detection of the mealybug.
- Prune off infested leaves, remove and burn them.
- Use high pressure water jets to dislodge and kill mealybugs.
- Prevent the movement of ants and destroy ant colonies, as ants defend the pest from its natural enemies and help spread the mealybugs.
- Clean farm equipment thoroughly before moving it to an uninfested crop.
- Conserve natural enemies like ladybirds, lacewings etc. by avoiding pesticide sprays and practising crop/plant diversity within the farm.
- Proper plant nutrition (fertilisation) enhances plant immunity/resistance against the mealybug and other pests.
- Add mulch to avoid crop moisture stress, which can make the mealybug problem worse.

- Classical biological control is the main and most appropriate control method against cassava mealybug, using the parasitoid *Apoanagyrus lopezi,* specific to *P. manihoti.* The parasitoids are very sensitive to pesticides, so insecticide spraying should be kept to a minimum (last resort).
- To control cassava mealybug, it is important to practice an integrated pest management area-wide approach, to prevent re-infestation.

**Note:** for all pesticide usage (last resort):

- Follow instructions on the product label.
- Wear appropriate protective clothing when applying pesticides.
- The wax coating on mealybugs protects them from insecticide sprays. Add a wetter or sticker to the insecticide for better penetration.
- Alternate pesticides with different active ingredients to avoid the development of resistance to pesticides.
- Use botanical pesticides e.g. neem that have low impact on natural enemies, the environment and human health.
- Use commercial horticultural oils which are less toxic to the natural enemies.

# Cassava white scale, *Aonidomytilus albus*

## Recognise the problem

*Aonidomytilus albus* is a tropical species that has been spread by transport of infested cassava cuttings for planting. It is polyphagous and attacks host-plants in 16 genera belong to 12 families; however, cassava and other species of *Manihot* are its preferred hosts. Other important hosts attacked by this pest include: papaya, mango, eggplant etc. The scale is only an occasional problem in the field; more often it is a problem on cassava stems stored for later planting. Infested cuttings often do not root, and planting of infested cuttings can result in rooting failure of up to 80%; the roots of infested plants become unpalatable. Heavy infestation causes desiccation of the stems, making them grow thin and weak, and break in the wind; death of the plant may result. Stem breakage results in profuse branching, so infested plants often look bushy. Crowded planting encourages the development and spread of infestations, whereas the use of clean planting material and wide spacing reduces the risk of serious infestation. The severity of attack is made worse by drought conditions, and heavy infestation aggravates drought stress. The socio-economic impact of this pest can be considerable, as cassava is an important staple crop during drought, e.g. in Kenya and the rest of Africa.

*Aonidomytilus albus* (Photo: (USDA ARS, Bugwood.org)

Cassava cuttings infested with A.albus

Cassava cuttings infested with A.albus

## Background

In the field, infestation of cassava will be noticed by the bushy appearance of the plants, with stems, side shoots and even sometimes the leaf petioles being coated with scales. Adult female *A. albus* feed throughout their lives and, once adult, live for several months. Adults have elongate mussel-shaped scale covers, usually silvery-white and about 2-2.5 mm long. Reproduction is sexual, with eggs hatching in 3-4 days and reaching maturity in 20-25 days. Crawlers are the primary dispersal stage and move to new parts of the plant or adjacent plants if they are touching; they are dispersed passively by wind or passing animals. Dispersal of sessile adults and eggs over long distances occurs through human transport of infested plant material.

## Management

- Practise crop rotation to limit and disrupt the life cycle of the pest.
- Practice good field hygiene – remove leftover cassava roots and shoots after harvest to prevent pest carry-over between one cassava crop and the next.
- The main infective stage of *A. albus* is the first-instar crawler, which is quite short-lived in the absence of food. Infested fields should therefore be left empty for at least 3 days before a new crop of cassava is planted nearby.
- Apply organic matter to improve soil fertility
- Select varieties/cultivars to plant that are resistant to or tolerant of the scales. This limits the impact of infestation and other indirect socio-economic impacts
- Inspect cuttings thoroughly before planting and destroy any scales.
- Dip cassava cuttings in 200 ppm malathion or diazinon to kill any infestation and store them vertically to limit introduction and spread.
- Space out cuttings and plants, and prune plant canopies to minimise the plant crowding that encourages the development and spread of *A. albus*.
- Scout the field regularly to detect the presence of the scales early.
- Remove heavily infested plant parts and destroy by burning or burial 50 cm deep.
- Avoid transport and/or movement of infested cassava between farms, especially through new cassava fields, to limit introduction and spread.
- Avoid use of pesticides in the cassava field or in neighbouring crops, as this may kill natural enemies.

# Citrus mealybugs, *Planococcus citri* and *Planococcus minor*

## Recognise the problem

*Planococcus citri* and *P. minor* look identical in life. Both are serious pests, damaging various crops such as citrus, grapes and mangoes, and can be the most injurious of the mealybugs on citrus. Damage is caused mainly by extraction of sap. Feeding on flower stalks, buds and young fruits causes wilting due to sap depletion. Attacks on leaves, fruits and stems lead to plant death in grapes. On citrus, feeding causes the formation of corky scars, causing a significant reduction in production in terms of fruit quality, weight and size. Fruit discoloration, fruit rind splitting and chlorotic spots have also been observed in oranges as a result of citrus mealybug infestation. *Planococcus citri* has been found to transmit plant virus diseases. The sugary honeydew ejected by citrus mealybugs falls on leaves and fruits below, resulting in the growth of sooty moulds, which impair photosynthesis by blocking light and air from the plant. Sooty mould on the fruits leads to commercially unacceptable disfigurement and reduced market value. Other crops including coffee, cocoa, grapes, yams and ornamental plants are also attacked by these mealybugs.

Adults and nymphs of *P. citri* being attended by ants (Photo: Ron Hemberger)

Adult females Planococcus minor (Photo: Richard Piper, Australia)

Adult Planococcus citri (Photo: California Department of Food & Agriculture)

## Background

Colonies of citrus mealybugs can be easily detected on fruits and inflorescences as white waxy masses. The females are wingless, up to 3 mm long, oval, white to yellowish or light brown with a coating of white powdery wax, with brown legs and antennae; each female has a characteristic darker longitudinal stripe along the dorsum, and produces a white cottony mass of wax at the posterior end, covering the eggs. The glossy, light yellow eggs are oval and approximately 0.3 mm long. Nymphs settle along midribs and veins on leaf undersides, young twigs and fruit buttons. They can also be found where two fruits are touching each other or on leaves clinging to fruits. Due to their habit of hiding in crevices, light infestations are easily overlooked. Adult males are winged and up to 4 mm long. Dispersal of citrus mealybugs may occur through crawlers actively walking, sometimes between trees if their canopies are touching; or passively by wind, on birds' feet, or on machinery and labour crews. Attendant ants, attracted by the sugary honeydew, defend the mealybugs from their natural enemies and frequently carry them from one tree to another.

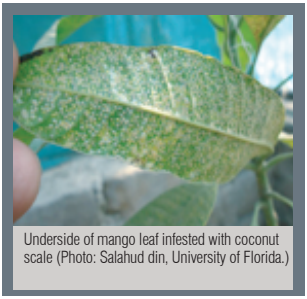
## Management

- Regular scouting to detect presence of the mealybugs early.
- Cut off infested plant parts and destroy them by burning, or burial 50 cm deep.
- Prevent pest spread by good orchard hygiene; remove and bury/burn prunings and crop residues.
- Remove weeds/alternate host plants like *Hibiscus*, etc. in and near the crop.
- Avoid the movement of planting material from infested areas to other areas.
- Prevent the movement of ants and destroy existing ant colonies.
- Clean farm equipment before moving it to another orchard with an uninfected crop.
- Use a strong jet of water to dislodge and kill mealybugs.
- Encourage the build-up of natural enemies like ladybirds by reducing and localising pesticide sprays, and practising crop/plant diversity within the farm.
- Use botanical pesticides e.g. neem that have low impact on natural enemies, the environment and human health.
- On large farms, fumigation of picking sacks and boxes is recommended to prevent the spread of citrus mealybugs between orchards.

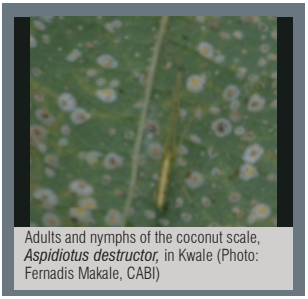
# Coconut scale, *Aspidiotus destructor*

## Recognise the problem

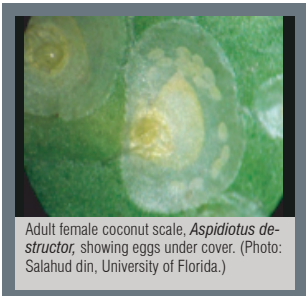
Coconut scale occurs in tropical and subtropical parts of the world. It is a polyphagous armoured scale insect that attacks perennial plants in more than 60 families. It sucks sap out of individual plant cells in leaves and green stems and injects toxic saliva as it feeds; no honeydew or sooty mould is produced. Perennial crops are attacked, especially coconut and other palms, fruit trees and bananas. On coconut, infestation is mainly on the lower surface of the leaves but frond stalks, flower clusters and young fruit can also be attacked. Heavy infestation causes the leaves to dry up, entire fronds to drop off, and the crown may die; the whole crop may be lost. Neglected plants are the most susceptible to damage by *A. destructor.* On oil palms the leaves and fruits are attacked, reducing fruit quality. On mangoes the scales attack older leaves, young, tender shoots and flowers, reducing fruit set and causing blemishes that reduce fruit aesthetic value and quality. Since it is polyphagous, *A. destructor* is readily reintroduced even after successful management on the primary host plant. Coconut scale has a relatively short life cycle (around 35 days) and multiple overlapping generations per year, and is dispersed mainly by birds, bats and insects, and the wind.



Underside of mango leaf infested with coconut scale (Photo: Salahud din, University of Florida.)



Adults and nymphs of the coconut scale, *Aspidiotus destructor,* in Kwale (Photo: Fernadis Makale, CABI)



Adult female coconut scale, *Aspidiotus destructor,* showing eggs under cover. (Photo: Salahud din, University of Florida.)

## Background

Infestations form closely packed colonies composed of scales resembling miniature translucent fried eggs. Females develop through two nymphal stages, while males have additional non-feeding pre-pupal and pupal stages (four immature stages). Adult female coconut scales have a circular or broadly oval cover 1.5-2.0 mm in diameter. The cover is flat and translucent with subcentral pale yellow cast skins. Adult male coconut scales are small, two-winged, reddish, gnat-like insects with eyes, antennae, three pairs of legs and long appendages; they do not feed and are short lived. Newly hatched crawlers are the primary dispersal stage of coconut scale within and between host trees, mostly by being blown on the wind.

## Management

- Regular scouting helps early detection and informs decisions on management.
- Prune off infested branches and destroy them by burning or burial 50 cm deep.
- Good orchard hygiene: remove and burn all infested crop residues.
- Plant spacing, or pruning to avoid canopies touching each other, limits spread.
- Clean equipment before moving from an infested area to an uninfested crop.
- Limit movement of possibly infested plant materials between orchards, farms and regions
- Conserve natural enemies like ladybirds and poarasitoids - limit chemical spraying, minimise dust etc.
- Use botanical pesticides e.g. neem that have a low impact on natural enemies, the environment and human health.
- Commercial horticultural oil emulsions can also be used - they kill scales by suffocation.

## Coffee green scales, *Coccus viridis* and *Coccus celatus*

### Recognise the problem

The two soft scale species called coffee green scale are indistinguishable in the field. They feed mostly on the leaves and green stems of plants in the coffee family (Rutaceae), but also on citrus, guava, soursop and other hosts. The scales suck out plant sap and expel large amounts of sugary honeydew that fouls plant surfaces, giving rise to growths of sooty mould. The mould turns leaves and stems black, blocking light and air from leaves and reducing photosynthesis. The sweet honeydew also attracts ants, which protect the scales from their natural enemies; this results in heavier infestations and greater levels of crop damage. Heavy infestation of mature coffee causes reduction in fruit set, drying and drop of berries, defoliation and loss of plant vigour. Attack on seedlings and young trees weakens them, turns the leaves yellow, and sometimes causes dieback or even plant death, with added expense for replanting. Yield losses of up to 50% have been reported as a result of infestation by coffee green scales.

Adult coffee green scales, ***Coccus celatus,*** on coffee stem (Photo: B.M. Shepard, Clemson University, U.S.A.)

Coffee green scale on coffee leaves. (Photo: Hawaiifeed.com)

Coffee green scales, (***Coccus viridis***) along the leaf midrib (Photo: R. J. Gill, ldtools.com)

### Background

Coffee green scale infestation forms a rather distinctive pattern on leaves. The lower surface of the leaf is preferred, and adult scales may be found in a line along both sides of the midrib and lateral leaf veins. Often, they attack the young shoots, forming a layer of scales. The adult female (about 2.5 to 3.25 mm long) is shiny light green with a conspicuous black, irregular U-shaped internal marking visible to the naked eye. The eggs hatch within hours of being laid, and there are three nymphal stages, all of which are capable of walking.

### Management

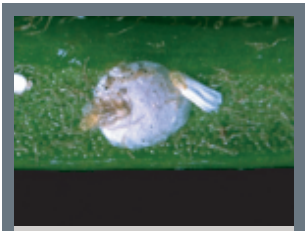
- Scout immediately after transplanting and then on a weekly basis. Look for shiny light green insects on the green wood and leaf undersides, especially along main leaf veins and near the tips of green shoots.
- Prune off old branches and leaves to enhance aeration through the canopy. Destroy any infested prunings by burning or burial 50 cm deep.
- Coffee green scale is often associated with attendant ants. Controlling ant populations helps to reduce levels of this pest. Ant nests in the soil can be killed with boiling water. Nests in the foliage can be pruned off into a bucket of boiling water.
- Band the trunks of coffee trees with a sticky non-drying glue (e.g., "Tanglefoot"), to prevent ants from climbing the trunk to attend the scales and drive off predators and parasitoids.
- To prevent ants climbing a tree, apply with a brush to the stem, 1 foot above the base, a 15 cm-wide band of a deltamethrin-based product such as Decis 2.5 EC, Atom 2.5EC etc. at the rate of 10-15ml/20L of water mixed with 15g of Methylene blue, which acts as a marker.
- Encourage/conserve natural enemies e.g. ladybird beetles and parasitoid wasps by sparsely planting shade trees such as species of *Grevillea, Leucaena* or *Macadamia.*
- Heavily scale-infested trees can be spot-treated with pesticides such as:
  - Mineral oils at 200 ml per 20 L of water.
  - Soap solution (potassium soaps). Add 10-15 tablespoons full of liquid soap to 20 L of water.
  - Botanical pesticides like neem.

**Note:** To achieve management of this scale, practice an integrated pest management approach on an area-wide scale, to avoid re-infestation.

# Cycad aulacaspis scale, *Aulacaspis yasumatsui*

## Recognise the problem

Cycad aulacaspis scale (CAS) is a pest specific to cycads and is native to Southeast Asia. It has been spread around the world through trade in cycad plants for ornamental use. These plants grow slowly and are expensive to buy. Infestation is initially on the undersides of leaves but as numbers increase, all surfaces of the plants are affected. Damage is caused through sucking cell sap and injecting toxic saliva, which causes chlorosis and death of the plant in a matter of months. The scale detracts from the appearance of plants even after treatment as the dead scales do not readily drop off. CAS also threatens to make several rare and already endangered endemic cycad species extinct in other parts of the world. The scale threatens the ornamental cycad-growing industry and endemic Kenyan endangered native cycad species. The spread of CAS to new areas is mainly through human trade in infested plants, while locally the first instar crawlers disperse by walking or are carried by passing animals or the wind. The scales can be extremely difficult to detect on whole cycad plants at plant quarantine inspection due to their small size and ability to hide in deep crevices or even on the roots.



Adult *Aulacaspis yasumatsui* (Photo: California Department of Food & Agriculture)

Exposed reddish brown female *Aulacaspis yasumatsui* (Photo: California Department of Food & Agriculture)

*Aulacaspis yasumatsui* killing cycads (Photo: Aunu Rauf, Bogor Agricultural University)

## Background

In the field, cycad leaves develop a whitewashed or snow-covered appearance due to a continuous crust of white scales. Heavily infested plants become chlorotic, with yellow-brown leaves, as the continuous removal of plant sap and injection of toxic saliva by the scales kills the leaves. CAS differs from other armoured scales found on cycads by the speed with which it multiplies and the density of the infestation. An infestation usually starts on the petioles near the crown of the plant, and spreads outwards. The plant will usually be totally covered within a couple of months.

Adult female *A. yasumatsui* have a waxy shield-like cover to protect themselves and their eggs. Scale covers of mature females are white, 1.2-1.6 mm long and highly variable in form. When the scale cover is lifted, the exposed live adult female is reddish brown; eggs beneath the scale cover are pale yellow when first laid, becoming reddish brown with age. Adult males (0.5-0.6mm long) are orange-brown, and resemble tiny flying midges, with one pair of wings and well-developed legs and antennae.

## Management

- Enforce strict quarantine regulations by prohibiting importation of cycad plants from infested countries.
- Avoid movement of infested plants between locations and regions.
- Carefully inspect planting material and reject and destroy any infested plants.
- Observe proper plant spacing to avoid plants touching each other – this may limit spread.
- Prune off infested fronds and burn or bury them on the spot.
- Remove and destroy infested plants or groups of plants more or less on the spot; transport of infectious material helps to disperse the crawlers. Crawlers can be blown by the wind over considerable distances; the direction of the wind should be taken into consideration.
- Clean pruning equipment thoroughly before moving to another plant.
- Washing infested plants with high-pressure water jets will dislodge scales and drown crawlers, reducing the severity of the infestation. Avoid splashing clean plants nearby, this could spread the infestation.
- Conserve natural enemies like ladybirds – avoid or minimise chemical spraying, dust etc.
- Use botanical pesticides e.g. neem that have low impact on natural enemies, environment and human health.
- Commercial horticultural oil can also be used - kills scales by suffocation.

## Cottony cushion scale, *Icerya purchasi*

### Recognise the problem

*Icerya purchasi* is a relatively large scale insect, over 5 mm long. It feeds on plant sap and eliminates copious quantities of sugary honeydew which coats the leaves, impeding gas exchange. Honeydew is a medium for the growth of sooty moulds over plant surfaces; this blocks light from the leaves, impeding photosynthesis. Damage by *I. purchasi* is mostly caused by sap depletion; the shoots dry up and die, defoliation occurs, and fruit quality and value is reduced. Ants are attracted to the honeydew eliminated by *Icerya purchasi* and protect the scales from the activity of natural enemies. *Icerya purchasi* is a particular pest of species of *citrus, Acacia*, *Casuarina* and *Pittosporum*. but can damage many types of fruit, forest and ornamental trees and shrubs. Unchecked infestations of cottony cushion scale can severely impact fruit-growing and horticultural industries, and native biodiversity.

*I. purchasi* reddish eggs. (Photo: J.Catalan)

Adult female *I. purchasi* with cottony ovisac (Photo: A. Urbaneja)

An advanced infestation of *I. purchasi* containing different life stages (Photo: M. Juan)

### Background

The adult female cottony cushion scale produces a distinctive elongated, fluted cottony white ovisac up to 2 times longer than the body; this ovisac contains reddish eggs and crawlers. The nymphs (all mobile) are orange-red with small white waxy secretions on the back and dark brown limbs. The adult female's body is orange-red or -brown with some yellowish-brown wax secretions, up to 7 mm long. The scales often occur in large groups. The adults are hermaphrodite; males are extremely rare. Dispersal over short distances is mainly by crawlers walking; over longer distances they are passively carried by wind currents, vehicles, animals, birds, or on clothing. Long-distance dispersal happens as a result of human transport of infested fresh plant materials. *Icerya purchasi* is usually found along major veins on the lower surfaces of the leaves, and on the stems. It congregates in large masses and is very conspicuous. Long-established infestations are often surrounded by sooty mould growth, and are often attended by ants.

### Management

- Select seedlings for planting that are free from scale insects.
- Monitor the field weekly to check for the presence of the scale. If scales are found, either prune off the infested parts and destroy them by burning or burial 50 cm deep, or kill the insects by crushing them with your fingers.
- Prune trees annually to prevent their canopies from touching, to stop crawlers walking from tree to tree.
- Clean equipment with water before using it on uninfested plants, to minimise spread.
- Conserve natural predators such as ladybirds and green lacewings by planting attractive flowering plants on the ridge or borders of the orchard.
- Reduce pesticide use; avoid the use of persistent and broad-spectrum pesticides. If necessary, spot-treat with a narrow-range horticultural oil emulsion (follow application instructions on the bottle). This is less disruptive to natural enemies and bees than many other insecticides.
- Control large populations of ants if they are tending the scales, since they defend them from attack by natural enemies. A barrier of glue like Tanglefoot painted around the tree trunk will stop ground-nesting ants reaching the scales. Tree-nesting ants can be pruned out of the canopy into a bucket and killed with boiling water.
- To prevent ants climbing a tree, apply with a brush to the stem, 1 foot above the base, a 15 cm-wide band of a deltamethrin-based product such as Decis 2.5 EC, Atom 2.5EC etc. at the rate of 10-15ml/20L of water mixed with 15g of Methylene blue, which acts as a marker.

**Note:** Management of *Icerya purchasi* is based on biological control, and rarely on the use of insecticides - the exception being the use of insecticides against ants. To achieve management of this scale, practice an integrated pest management approach area-wide, to avoid re-infestation.

# Breadfruit mealybug, *Icerya aegyptiaca*

## Recognise the problem

*Icerya aegyptiaca* is widespread in tropical and subtropical regions. It is polyphagous on mostly woody host-plants, attacking hosts in 113 genera belonging to 59 families. Breadfruit is the primary host but avocado, banana, citrus, jackfruit, mango, soursop, taro, and ornamentals are also attacked. The insects suck up phloem sap, depriving the host of water and nutrients; they eject copious sugary honeydew that coats nearby surfaces and gives rise to sooty mould growths. Sooty mould blocks light and air from the leaves and impedes photosynthesis. Infestation causes leaves to dry up, die and drop; heavy infestations can kill mature breadfruit trees, but more often the trees are partially defoliated and the crop may be reduced by 50% or more. The sweet honeydew attracts attendant ants, which defend the breadfruit mealybugs from natural enemies like ladybirds and carry the crawlers to new feeding sites, making the pest problem worse. Outbreaks normally occur in areas with little wind flow, such as the inner parts of the canopy. Prolonged dry weather favours an increase in the population, so populations may vary from year to year.

*Icerya aegyptiaca* on croton (Fernadis Makale, CABI)

Adult *Icerya aegyptiaca* on a guava leaf, showing the long white waxy fringe around the body. (Photo: Peter A.C. Ooi, CABI BioScience)

Adult breadfruit mealybug, *Icerya aegyptiaca* (Photo: California Department of Food & Agriculture.)

## Background

Adult *I. aegyptiaca* have orange-red bodies with black legs and antennae, and are covered by thick layer of white wax. The species reproduces asexually (without fertilisation/mating); males are absent or unknown. Each female lays 70 to 200 oval, yellowish-orange eggs (depending on temperature and host quality) into an egg sac of fluted white wax. These hatch into active crawlers that become covered in wax. On breadfruit, the crawlers settle along the midribs and larger veins on leaf undersides, and on the fruit. Dispersal is by first-instar crawlers walking to other leaves, or by being carried on the wind to other plants. Movement of fresh plant material and contaminated pruning equipment between farms also aids in the dispersal of breadfruit mealybug.

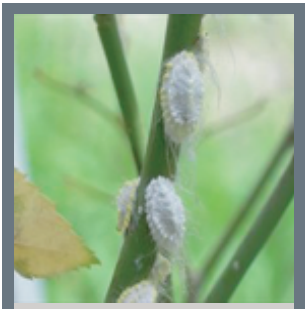
## Management

- Check the orchard regularly to detect the presence of the mealybugs early.
- Prune infested stems, branches and fruits and destroy them by burning, or burial 50 cm deep.
- Apply mulch, manure or synthetic fertilizers in moderation to boost plant vigour; but excessive use of fertiliser may help the scales to develop large numbers.
- Prevent the movement of ants with a sticky band (e.g. Tanglefoot) around the tree trunk, and destroy existing ant colonies with boiling water or insecticides. Chemicals presently being used in Kenya against the attendant ants include Supracide, Chlorpyrifos and Rhodocide.
- Conserve natural enemies e.g. ladybirds and parasitic wasps by avoiding use of broad-spectrum insecticides, reducing dust, and practising crop/plant diversity within the farm.
- Use a strong jet of water to dislodge and kill mealybugs.
- Note that the wax covering the mealybugs reduces the effectiveness of most chemical insecticides.
- Spot-treat colonies with a soap solution made by dissolving a finger-sized piece of bar soap in 20 litres of water; or use botanical pesticides like neem extract, or a horticultural oil emulsion, that have low impact on natural enemies, the environment and human health.
- As a last resort, for heavy infestations, spot-treat with synthetic pesticides.

## Seychelles scale, *Icerya seychellarum*

### Recognise the problem

*Icerya seychellarum* has a wide distribution across Africa, Asia and Oceania. It is polyphagous on mostly woody hosts, reported on members of over 60 plant families. Some common hosts are avocado, breadfruit, *Casuarina*, citrus, *Ficus* and guava. The insects suck phloem sap and produce copious sugary honeydew waste, which fouls nearby surfaces. This is a medium for sooty mould growth; the mould blocks light and air from the leaves, impairing photosynthesis and gaseous exchange. The mould is also unsightly, reducing the marketability of fruit. Infestation results in yellowing of leaves, leaf drop, reduced plant growth/vigour, death of young shoots and, sometimes, the death of plants. The scales are often attended by ants, which eat the honeydew and defend the scale insects from attack by predators and parasites, making the pest problem worse.



*Icerya seychellarum* adults, showing long wax filaments and yellow-and-white wax coverings (Photo: Pestnet.org)

Adult *Icerya seychellarum* being attended by ants (Photo: Pestnet.org)

Infestation of *Icerya seychellarum,* showing different developmental stages along the leaf midrib and veins (Photo: Pestnet.org)

### Background

In adult *Icerya seychellarum* the limbs are dark brown to black; the body contents are orange-red and the dorsum is covered in white or white-and-pale yellow powdery wax, with fine wax threads projecting from the body. The insects feed mainly on the undersides of leaf veins and on stems, less often on twigs and fruit. Adults have both male and female sex organs, but can give birth to living young without mating. The winged males are very rare. The first-stage nymphs (crawlers) are the primary dispersal stage, either walking or being passively dispersed by being blown on air currents (wind), hitch-hiking on clothes, passing animals etc; or by transport of nymphs by the attendant ants. Over long distances, the scales are carried by human transport of infested plant material.

### Management

- Prune off infested stems, branches and fruits and burn them.
- Apply mulch, manure or synthetic fertilizers in moderation to assist plant vigour.
- Destroy ant nests with boiling water, without damaging the plants infested with the scale insect; this will increase the activity of natural enemies (parasitoids and predators) and help bring about natural control of the scale insects.
- Conserve natural enemies e.g. ladybird beetles and parasitic wasps by avoiding use of chemical pesticides; also maintain hedges containing diverse plants to attract natural enemies.
- If necessary, use commercial horticultural oil emulsion and/or soap solution spot sprays to control this pest.

## Ensign scale, *Insignorthezia insignis*

### Recognise the problem

*Insignorthezia insignis* originated in the Caribbean; outside this region it has been reported as a pest in drier climatic zones where it has been accidentally introduced, and as a glasshouse pest in subtropical and temperate regions. The scale sucks large quantities of phloem sap from plants, causing wilting and general host debilitation. It eliminates copious amounts of sugary honeydew that fouls nearby surfaces, giving rise to sooty mould growth. Sooty mould blocks light and air from the leaves, impairing photosynthesis and gaseous exchange, resulting in reduced plant growth. Badly fouled leaves may drop prematurely and the quality and market value of fruits and ornamental plants may be reduced. Ants attending the scales for their honeydew help to protect them from the natural enemies that would otherwise control the scale population. *Insignorthezia insignis* was considered as a possible biological control agent for the notorious weed *Lantana camara* but due to its polyphagous nature it was unsuitable.

Adult *I.insignis* (Photo: R. Muniappan, and Viraktamath)

*Insignorthezia insignis* infestation (Photo: Scott Nelson)

Greenhouse Orthezia (Insignorthezia insignis) (Photo: Flickriver)

### Background

*Insignorthezia insignis* mainly feeds on perennial shrubs and trees. Unlike most scale insects, the adult female forms a fluted white ovisac up to 2 mm long attached to her abdomen, rather than attaching it to the plant. Older females are conspicuous on young stems, especially when they walk about and the movement of the white ovisacs catches the light. Each adult female is brownish olive green and about 1.5 mm long and 1.3 mm wide; the dorsum is mostly bare of wax except for two narrow longitudinal rows of small white wax processes. Dispersal occurs at the first instar (crawler) stage, either by walking or by passive dispersal by wind or on passing animals; they are very small, light and can survive several days without feeding. Accidental introductions to new countries occur due to human trade in infested planting material.

### Management

- Select seedlings for planting that are free from scale insects.
- Monitor perennial and woody crop plants weekly to check for the presence of scales.
- Prune off infested plant parts and destroy them by burning or burial 50 cm deep.
- Prune trees annually to prevent their canopies from touching. This prevents scales from walking from one tree to another.
- Clean equipment thoroughly with water to wash off scales before using it in uninfested parts of the field, to minimise spread.
- Observe good orchard hygiene - remove and bury or burn crop residues.
- Conserve natural predators such as ladybirds and green lacewings by planting attractive flowering plants on the ridge or border of the orchard.
- *Insignorthezia insignis* is a difficult scale insect to control by chemical means due to the water-repellent properties of its waxy plates. Sprays containing soaps are more effective than other pesticides.
- Use botanical pesticides e.g. neem that have low impact on natural enemies, the environment and human health.

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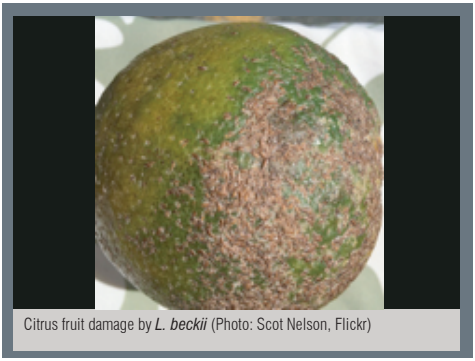
# Citrus mussel scale, *Lepidosaphes beckii*

## Recognise the problem

*Lepidosaphes beckii* originated in Asia but is now widely distributed throughout the tropical and subtropical regions of the world. It is polyphagous and has been recorded from hosts in 56 plant genera belonging to 40 families. Important hosts attacked include citrus, mango, avocado, guava, passion fruit etc. *Lepidosaphes beckii* is one of the most important pests of citrus wherever it is grown. The nymphs and adult females suck out cell contents in the foliage and branches and inject toxic saliva, which causes leaves to turn yellow and drop, weakening the tree and reducing productivity. Infestation of the fruits causes disfiguration and poor maturation, and the sites where the scales have fed remain green at colour change; this greatly decreases the market value of fruits and can make them unmarketable. The scale does not produce honeydew or cause sooty mould.



Citrus fruit damage by *L. beckii* (Photo: Scot Nelson, Flickr)

Adult female *L. beckii* on citrus fruit (Photo: California Department of Food & Agriculture)

## Background

In the field, the adult female scale cover is elongate and wider at one end, about 2.5-3.5 mm long, mid-brown or purplish brown with a small red spot near the narrow end. It is found on bark, stems, leaves and fruit. The insects prefer shade so infestations are usually heaviest at the centre of the canopy and on northern aspects but can go unnoticed due to the cryptic colour of the scale. *Lepidosaphes beckii* reproduces either sexually or parthenogenically and each female lays 40-100 eggs, which hatch about 8 days later. Up to four generations may be produced each year, depending on climatic conditions. The first-instar crawler is responsible for dispersal by walking, and by being passively carried between hosts by wind or on animals. Long-distance dispersal of the sessile adults and eggs occurs through human transport of infested plant material.

## Management

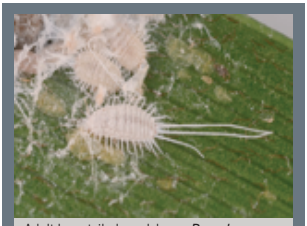
- Avoid movement of infested plants between locations, farms and regions.
- Carefully inspect planting material and reject and destroy any infested plants.
- Observe proper plant spacing to avoid plants touching each other, and prune trees to prevent their canopies touching – this helps to limit scale insect spread between trees.
- Scout the orchard regularly to detect the presence of the scales early.
- Prune off infested plant parts; remove and destroy them by burning or burial 50 cm deep.
- Clean pruning equipment thoroughly before moving to another plant.
- Conserve natural enemies like ladybirds – avoid or minimise chemical spraying, dust etc. Control ants in the trees, as they attack the natural enemies of scales and can interfere with biological control. Biological control using parasitoids and coccinellid beetles is effective against this pest.
- If necessary, spot treat affected trees as opposed to the whole tree/farm.
- Use soap solution or botanical pesticides like neem extract, or commercial horticultural oil emulsion, that have low impact on natural enemies, the environment and human health.
- Implement/practice an integrated pest management program combining cultural methods, physical methods, botanicals e.g. neem extract and natural enemies.
- Only as a last resort, spot-treat infestations with a narrow spectrum pesticide.

# Long-tailed mealybug, *Pseudococcus longispinus*

## Recognise the problem

*Pseudococcus longispinus* is a widely-distributed pest that feeds on many economically important plants, particularly tropical fruits and ornamentals. Like many other sap-sucking insects, it feeds directly on the plant's vascular system. As the insect feeds, a sugary liquid called honeydew is periodically eliminated by the insect. The honeydew coats nearby surfaces and nourishes a growth of black sooty mould. The mould is unsightly, hard to remove, and blocks light and air from the leaves, impeding photosynthesis. It also disfigures fruits grown for fresh consumption, reducing their market value or making them unmarketable. This cosmetic damage also affects the value of ornamental plants. The sugary honeydew also attracts ants (e.g. *Technomyrmex difficilis*), which defend the mealybugs from their natural enemies and distribute the mealybugs to new feeding sites.

Heavy infestation by *P. longispinus* may cause fruit shrinkage and premature leaf and fruit drop, e.g. on avocado and citrus. On pears (*Pyrus* sp.), infestations on fruit can cause uneven ripening. In addition, *P. longispinus* is an efficient vector of *Grapevine leafroll-associated virus 3* (GLRaV-3), which causes grapevine leafroll disease.



Adult long-tailed mealybugs, ***Pseudococcus longispinus*** (Photo: Morgan A. Byron, University of Florida.)

Colony of Long-tailed mealybugs, ***Pseudococcus longispinus*** (Photo: Giuseppina Pellizzari)

Adult *P. longispinus* (Photo: D.Kuru, Wikimedia)

## Background

The long-tailed mealybug is easily recognised by the last abdominal segment of the adult female having two protruding slender white waxy filaments, often as long as the body itself. This distinguishes the species from other mealybugs that may feed on the same host plants. The long-tailed mealybug reproduces sexually. The male has one pair of wings but the female lacks wings and is only capable of crawling. The adult female's body is about 3 mm long, oval and yellowish grey, sometimes with a slightly darker longitudinal stripe on the midline. The body is covered with powdery white wax and is surrounded by long, slender white wax filaments. The main way that the mealybugs disperse is by the tiny crawlers actively walking from infested to uninfested plants or passively, by being carried by the wind. Long-distance dispersal happens as the result of human transport of infested plant material from one area to another.

## Management

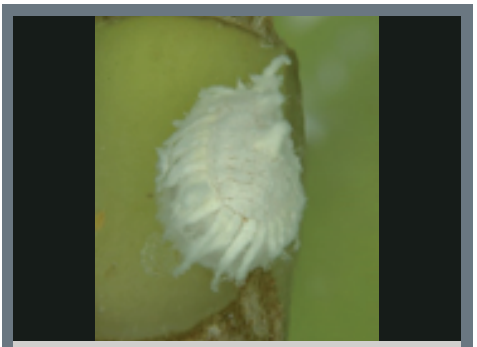
- Look for small, oval insects with long slender white tails (up to 1x the body length) and a darker median stripe running down the back.
- Cut off heavily infested plant parts like stems or leaves and destroy them by burning, or burial 50 cm deep.
- Prevent pest spread by good field hygiene; dispose of prunings and crop residues through burning or burial.
- Control ant populations, as they protect the mealybugs from their natural enemies.
- Use a strong jet of water to dislodge and kill mealybugs.
- Use a spray of soap solution (one bar of soap in 20 L of water) to remove mealybug infestations from plants.
- Apply a spray of 1-2% vegetable oil (e.g. neem oil) to plants (10 ml of liquid soap to 1 litre of water, then mix in 50 ml of neem oil).
- On the trunks of trees, apply a sticky band, e.g. Tanglefoot (5 cm wide) on the bark to prevent pests and ants crawling up to the leaves and fruit.
- Avoid the use of broad-spectrum pesticides to preserve natural enemies of mealybugs (lacewings, pirate bugs, lady beetles) and parasitoids.

# Mango coccid, *Rastrococcus iceryoides*

## Recognise the problem

Mango coccid is native to Asia, but arrived in Kenya many years ago. It has been reported on over 65 host plants from 35 families; important hosts that are sometimes damaged are cotton, citrus, coffee, kapok, mango and cocoa. The insects suck phloem sap and eliminate copious sugary honeydew, which fouls nearby surfaces and provides a medium for sooty mould growth. The mould blocks light and air from the leaves, impairing photosynthesis and gaseous exchange. Infestation results in leaf yellowing and desiccation, drop of leaves and inflorescences, poor fruit set, and fruit drop. Mango seedlings in nurseries may be attacked. The honeydew attracts attendant ants that feed on it. While doing so, they protect the mealybug from natural enemies, clean up waste that would otherwise be detrimental to the first instars and also help in spreading the mealybug. Due to the waxy coating, routine chemical applications have proven insufficient and inefficient against this pest.

Adult mango coccid on a mango twig (Photo: Takumasa (Demian) Kondo)



Adult female mango coccid (Photo: http://nrcb.res.in/)

## Background

The adult female is broadly oval and slightly rounded to convex in lateral view. There are nine to ten generations per year. Reproduction is sexual and each female lays 450-585 eggs in a white, wax ovisac under the body. The first-instar nymphs settle on leaf undersides on terminal shoots but migrate to twigs when the population increases. The adult male has one pair of wings, well-developed limbs, lacks mouthparts and lives only a few days. Local spread of this pest happens as a result of crawlers walking, or being blown by wind and as hitch-hikers on agricultural equipment or passing animals or people. Long-distance dispersal is due to human transport of infested plant material from one orchard, country or region to another.

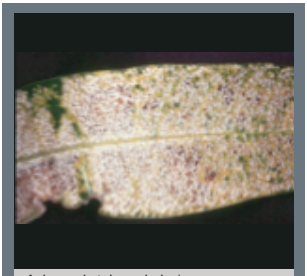
## Management

- Use clean planting material. Check seedlings for infestation before planting. This reduces the chance of introducing mealybugs to your orchard.
- Regularly monitor the plants/orchard to detect the mealybug early. This helps to make early management decisions and reduces the costs of a full-blown infestation.
- Remove alternate hosts from near the main crop. These plants serve as re-infestation sources.
- Destroy ant colonies in the orchard. This helps reduce the spread of mealybug and enhances the activity of natural enemies.
- Practice good orchard hygiene; prune off and burn infested plant material to avoid spread in the orchard.
- Clean equipment after use, before moving between orchards.
- Conserve natural enemies e.g. ladybird beetles that help to reduce the mealybug populations, by avoiding synthetic pesticide use (especially the broad-spectrum ones)
- Use neem extract or garlic oil to manage this pest.
- Practice IPM, integrating the different control strategies to achieve the best results.
- For heavy infestation, spot treat with synthetic insecticides as last resort.
    - Apply: Dimethoate (2 ml/litre) / Profenophos (2 ml/litre), Chlorpyriphos (5 ml/litre) / Buprofezin (2 ml/litre) / Imidacloprid (0.6 ml/lit) / Thiamethoxam (0.6g/litre)

# White mango scale, *Aulacaspis tubercularis*

## Recognise the problem

*Aulacaspis tubercularis* is a native of Asia but is now widely distributed in tropical and sub-tropical countries. It is polyphagous, and has been recorded feeding on plants in 30 genera belonging to 18 families. Important hosts include avocado, citrus, coconut, ginger, pumpkins and mango; it is a major pest of mango, attacking all parts of the tree above ground. *Aulacaspis tubercularis* sucks out cell contents and injects toxic saliva, causing chlorotic and necrotic areas around and under the scales, and can cause leaves to drop, weakening the tree and reducing productivity; on the fruits it causes conspicuous pink blemishes around the feeding sites of the scales, affecting their commercial value and export potential. In nurseries, severe infestation of young mango trees retards growth; saplings are particularly vulnerable to excessive leaf loss and twig dieback due to the scale, especially in hot dry weather. Most damage is caused to late-maturing mango cultivars. The scale does not produce honeydew or cause sooty mould.



*Aulacaspis tubercularis* damage on mango leaf (Photo: Tukumasa Kondo)

Mango fruit damage by *Aulacaspis tubercularis* (Photo: Tukumasa Kondo)

Female cover and feeding damage of *A. tubercularis* (Photo: California Department of Food & Agriculture.)

## Background

Reproduction in *A. tubercularis* is sexual. The scale cover of the female is white, almost circular, flimsy and semi-translucent, 1.5-3.0 mm in diameter, with small cast skins at one edge of the cover; the cast skins are usually pale yellow with a dark brown median stripe. The scales are mainly found on leaves, fruits and twigs. Under the scale cover the adult female is elongate and dark brown. The immature male scale covers are smaller, pure white, parallel-sided with 3 longitudinal ridges, and occur in tight groups, usually on leaves, killing the tissue beneath them. Each female produces 80-200 eggs under the scale cover that remain there until the crawlers hatch. Breeding continues through the wet and dry seasons. Depending on temperature, 5-6 overlapping generations may be produced per year. First-instar crawlers are responsible for dispersal; they may crawl several centimetres before settling, or may be dispersed passively by wind or passing animals. Dispersal of sessile adults and eggs over longer distances occurs through human transport of infested plant material.

## Management

- Avoid movement of infested plants between locations, farms and regions.
- Carefully inspect planting material and reject and destroy any infested plants.
- Observe proper plant spacing to avoid plants touching each other, and prune trees to prevent their canopies touching – this helps to limit scale insect spread between trees.
- Scout the orchard regularly to detect the presence of the scales early.
- Prune off infested plant parts and destroy them by burning, or burial 50 cm deep.
- Remove and destroy infested plants or groups of plants more or less on the spot; transport of infectious material helps to disperse the crawlers, which can be blown by the wind over considerable distances so the direction of the wind should be taken into consideration.
- Clean pruning equipment thoroughly before moving to another plant.
- Conserve natural enemies like ladybirds – avoid or minimise chemical spraying, dust etc and maintain crop/plant diversity within the farm. Control ants in the trees, as they attack the natural enemies of scales and can interfere with biological control. Biocontrol involving parasitic wasps and coccinellid beetles have been used successfully against this pest.
- If necessary, spot treat affected trees, as opposed to the whole tree/farm.
- Use soap solution or botanical pesticides like neem extract, or commercial horticultural oil emulsion, that have low impact on natural enemies, the environment and human health.
- Implement an integrated approach against this pest by combining cultural, biological, physical and (only as a last resort) chemical strategies.

# Mango shield scale, *Milviscutulus mangiferae*

## Recognise the problem

*Milviscutulus mangiferae* is a polyphagous tropical and sub-tropical scale pest, with host-plants in 82 genera belonging to 42 families. Its main host is mango; other important hosts include breadfruit, citrus, papaya, guava, avocado and ornamentals like *Hibiscus*. It is a serious pest of mango in various parts of the world. The scales suck up phloem sap and eject copious sugary honeydew, which coats nearby surfaces and gives rise to sooty mould growths. The sooty mould blocks light and air from the leaves, impairing photosynthesis. Leaves may drop and branches dry up. Sooty mould on the fruit reduces their commercial value and, if washed off, raises production costs. Very heavy infestations cause reduced tree vigour and leaf size, leaf yellowing and premature drop, yield loss, and decline or even death of the tree. The honeydew produced attracts attendant ants, which defend the scales from their natural enemies and may spread the infestation to new feeding sites, making the problem worse. The presence of this scale may increase production costs in orchards and nurseries as some growers are likely to treat. The scale insect also has the potential to disrupt markets by disfiguring citrus and avocado fruit as well as nursery stock.

*Milviscutulus mangiferae* (Photo: Lyle Buss, ldtools.org)

*Milviscutulus mangiferae* adult female on green leaf (Photo: California Department of Food & Agriculture)

*Milviscutulus mangiferae* adult female on stripped leaf (Photo: California Department of Food & Agriculture)

## Background

*Milviscutulus mangiferae* mainly feeds on leaf undersides. The adult female is rounded-triangular to oval, and flat to slightly convex in lateral view. Young adults are transparent to yellow-green, whereas older females become brown. Reproduction is mostly asexual; males are absent or rare. No ovisac is formed, so eggs are laid under the body of female. The first-instar crawlers walk short distances and settle on leaf undersides; the early developmental stages are transparent and difficult to see. There are usually two generations annually.

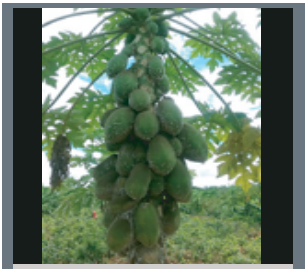
## Management

- Use clean planting material. Check seedlings for infestation before planting. This reduces the chance of introducing scales to your orchard.
- Regularly monitor the orchard to detect the scale early. This helps to make early management decisions and reduces the costs of a full-blown infestation.
- Remove alternate hosts from near the crop. These plants serve as re-infestation sources.
- Prune low branches and remove weeds to stop ants reaching the leaves and fruits.
- Prevent the movement of ants with a sticky band (e.g. “Tanglefoot”) around the tree trunk, and destroy existing ant colonies with boiling water or insecticides. Chemicals presently being used in Kenya against the attendant ants include Supracide, Chlorpyrifos and Rhodocide.
- Practice good orchard hygiene; cut off infested plant parts and destroy them by burning, or burial 50 cm deep, to avoid spread in the orchard.
- Clean equipment after use, before moving between orchards.
- Encourage the build-up of natural enemies e.g. ladybird beetles and parasitic wasps which will help to reduce the scale populations, by not using synthetic pesticides (especially the broad-spectrum ones) and by practising crop/plant diversity within the farm.
- Treat with a soap solution (made by dissolving a finger-sized piece of bar soap in 20 litres of water), or neem extract or garlic oil, or a horticultural oil emulsion, that have low impact on natural enemies, the environment and human health.
- Practice integrated pest management, by combining different control strategies to achieve the best results.
- As a last resort under heavy infestation, spot treat with synthetic insecticides: apply Dimethoate (2 ml/litre), or Profenophos (2 ml/litre), or Chlorpyriphos (5 ml/litre), or Buprofezin (2 ml/litre), or Imidacloprid (0.6 ml/lit), or/ Thiamethoxam (0.6g/litre).

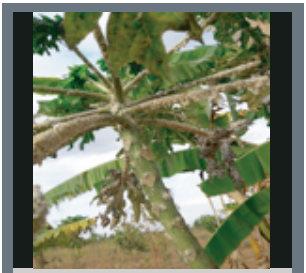
## Papaya mealybug, *Paracoccus marginatus*

### Recognise the problem

Papaya mealybug is polyphagous and feeds on a wide range of crops, fruits, ornamental and weed plants belonging to many plant families. The mealybugs insert their stylets into fruits, leaves and stems to feed directly on the plant's vascular system, depleting the sap. This results in chlorosis, plant stunting, leaf deformation and eventual plant death if the infestation is not controlled. As the mealybugs feed, sugary honeydew is periodically eliminated. This coats nearby surfaces and nourishes a growth of black sooty mould. The mould is unsightly, hard to remove, and blocks light and air from the leaves, impeding photosynthesis. It also disfigures fruits, reducing their market value or making them unmarketable. Sooty mould disfigurement also affects the value of ornamental plants. The sweet honeydew from the mealybugs attracts ants to feed on it. The ants protect the mealybugs from their natural enemies and move the mealybugs around, spreading the infestation. Heavy infestations make pawpaw fruits hard and bitter so they are inedible and unsaleable; this can result in heavy economic losses to affected farmers and abandonment of pawpaw farming.



Infestation by papaya mealybug on pawpaw fruits (Photo: Fernadis Makale, CABI)



Papaya mealybug infestation on pawpaw leaf stalks (Photo: Fernadis Makale, CABI)

Heavy papaya mealybug infestation on pawpaw fruits (Photo: Fernadis Makale, CABI)

### Background

Papaya mealybug infestations are typically observed as clusters of cotton-like masses on the above-ground portion of infested plants, usually on fruits and lower leaf surfaces; however, all surfaces of the plant are attacked in a heavy infestation. Adult females are wingless, have yellow body contents and are covered with a white powdery wax coating. Each adult female is approximately 2.2 mm long and 1.4 mm wide, with a series of short waxy filaments around the margin, each less than 1/4x the length of the body. Adult males are winged and approximately 1.0 mm long, with an elongate oval body that is widest at the thorax (0.3 mm). Local dispersal occurs through active walking of the crawlers from infested to uninfested plants, or passively by wind, rain, irrigation water, birds, ants etc. Long-distance dispersal is mainly through human transport of infested fresh plant material such as pawpaw fruits and other vegetative parts from one farm to another, or one area to another.

### Management

- Avoid the movement of planting material from infested areas to other areas - institute strict domestic quarantine measures between counties.
- Use clean planting material. Source planting material from certified nurseries.
- Scout regularly to detect the presence of the mealybug early.
- Prune off infested leaves and destroy them by burning or burial 50 cm deep.
- Observe orchard hygiene - remove and bury or burn crop residues.
- Remove weeds/alternate host plants like *Hibiscus*, etc. from near the crop.
- Destroy already existing ant colonies in the field.
- Apply sticky bands or alkathene sheeting or a band of insecticide around the trunks of each pawpaw tree and other host plants, to prevent movement of attendant ants carrying mealybugs.
- Clean farm equipment before moving it to a field with an uninfected crop.
- Use a strong jet of water to dislodge and kill mealybugs.
- Encourage the build-up of natural enemies like ladybird beetles by reducing pesticide sprays and practising crop/plant diversity within the farm. Some of the registered mealybug destroyer products in Kenya include Cryptobug and Cryptobug-L.
- Use botanical pesticides, e.g. neem, that have a low impact on natural enemies, the environment and human health.

- Spot-treat with recommended chemical insecticides as the last resort, e.g. Chlorpyrifos methyl 400g/L (20ml/20L), Buprofezin 400g/L (15ml/20L), Diazinon 600g/L (16ml/20L or 80ml/ha), Alpha cypermethrin 100g/L (16ml/20L or 80ml/ha), *Metarhizium anisopliae* (4ml/20L or 200ml/ha), imidacloprid 17.8 SL (0.6 ml/litre), etc.

**Note:**

- For all pesticide usage, follow the instructions on the product label.
- Wear appropriate protective clothing when applying pesticides.
- Include a wetter or sticker in the insecticide mix for better penetration, as the mealybugs have a waterproof waxy coat.
- To avoid the development of resistance to pesticides, alternate different active insecticidal agents in successive applications.
- To achieve good results, it is important to practice an integrated pest management approach on an area-wide scale to prevent re-infestation from nearby farms.

## Oleander mealybug, *Paracoccus burnerae*

### Recognise the problem

The oleander mealybug, *Paracoccus burnerae,* is a tropical species native to southern and eastern Africa; it is now known to be in at least 7 African countries, including Kenya. The mealybug is highly polyphagous, feeding on host-plants in 41 genera belonging to 24 plant families. Its hosts include commonly cultivated plants like citrus, coffee, guava, passion fruit, cotton, potato and ornamentals. Leaves and fruits are attacked. *Paracoccus burnerae* is ranked amongst the three most important mealybug pests of citrus, causing extensive leaf rolling. It can outcompete other citrus mealybug pests, especially *Planococcus citri,* when they occur together. *Paracoccus burnerae* feeds on phloem sap and eliminates copious sugary honeydew that fouls the plant surfaces and gives rise to sooty mould growths; this blocks light and air from the leaves, impairing photosynthesis. The sooty mould disfigures fruit, reducing its market value, and washing the mould off adds to production costs. *Paracoccus burnerae* is also a vector of plant virus diseases like *Banana streak virus*.

Adult *Paracoccus burnerae* (Photo: Tatiana MASTEN MILEK, Bulletin of Insectology)

### Background

The adult female of *P. burnerae* is elongate oval, covered by layer of mealy white wax but with body segmentation visible. The mealybugs occur on all parts of citrus branches (stems, leaves and fruit) throughout the year but migrate to fruits in dry conditions when the leaves become less palatable; others seek shelter in rolled-up leaves and under the dry remains of sooty mould. The colonies form conspicuous white waxy masses on fruits and inflorescences. *Paracoccus burnerae* reproduces sexually, and the rate of development is dependent on temperature. Dispersal is by the first-instar crawlers actively walking, sometimes between trees if their canopies are touching; or passively on the wind, birds' feet, or on agricultural machinery and labour crews. Attendant ants, attracted by the sugary honeydew, defend the mealybugs from their natural enemies and frequently carry them from one tree to another, making the pest problem worse.

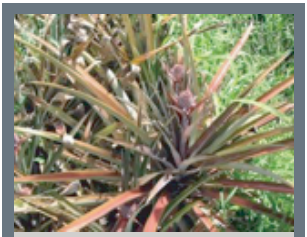
### Management

- Avoid the movement of planting material from infested areas to other areas.
- Remove weeds and alternate host plants like *Hibiscus* from in or near the crop.
- Check the orchard regularly to detect the presence of the mealybugs early.
- Cut off infested plant parts and destroy them by burning, or burial 50 cm deep.
- Prevent pest spread by good orchard hygiene; remove and bury or burn prunings and crop residues.
- Prevent the movement of ants with a sticky band (e.g. Tanglefoot) around the tree trunk, and destroy existing ant colonies with boiling water or insecticides. Chemicals presently being used in Kenya against the attendant ants include Supracide, Chlorpyrifos and Rhodocide.
- Clean farm equipment before moving it to another orchard with an uninfested crop. On large farms, fumigation or washing of used picking sacks and boxes is recommended to prevent the spread of citrus mealybugs between orchards.
- Encourage the build-up of natural enemies like ladybirds by reducing and localising pesticide sprays, and practising crop/plant diversity within the farm.
- Use a strong jet of water to dislodge and kill mealybugs.
- Spot-treat colonies with a soap solution made by dissolving a finger-sized piece of bar soap in 20 litres of water; or use botanical pesticides like neem extract, or a horticultural oil emulsion, that have low impact on natural enemies, the environment and human health.
- For heavy infestations, spot-treat with synthetic pesticides as a last resort.

# Pineapple mealybug, *Dysmicoccus brevipes*

## Recognise the problem

The pink pineapple mealybug is a pest of pineapple and other crops, and has been reported in almost all areas where pineapple is cultivated. Its damage to pineapple is due to its ability to transmit *Pineapple mealybug wilt-associated virus* to pineapples, which is a serious threat to commercial pineapple production. This mealybug is also able to transmit *cocoa Trinidad virus*. *Dysmicoccus brevipes* is highly polyphagous (attacking plants in more than 100 plant genera belonging to 53 families). Other crops attacked include avocado, banana, carrot, celery, *Citrus,* cocoa, coconut, coffee, cotton, ginger, *Hibiscus,* mulberry, orchid pineapple, taro, pumpkin and many perennial grasses. The mealybugs suck sap from plant vascular tissues. In pineapple, feeding damages the fruit directly, causing chlorotic (yellow) areas, rotted fruit bottoms, and mealybug stripe (streaks of discoloration with underlying tissue collapse). Feeding also weakens the plant, increasing its susceptibility to other pests and diseases. Black spot in pineapple develops due to mealybugs feeding in the blossom cavities, causing wounds that can enable the entry of fungal spores. Damage to other hosts reduces vigour and causes general weakness; yellow spotting on the undersides of leaves, which may be shed prematurely; stem dieback and wilting. Sugary honeydew eliminated by the mealybugs fouls the leaves and fruit and serves as a medium for the growth of black sooty moulds. Sooty moulds block light and air from the leaves, reducing photosynthetic area and greatly impairing gaseous exchange. Ornamental plants and produce lose market value. Pineapple mealybug is attended by ants attracted to its honeydew; the ants herd the mealybugs and protect them from their natural enemies, and occasionally carry the mealybugs to new host plants.



Plants showing pink, rolled, leaves typical of pineapple mealybug wilt disease. The "wilt" symptoms are due to root decay, caused by virus infection (Photo: United States National Collection of Scale Insects Photographs, USDA Agriculture Research Service.)

An adult pineapple mealybug, *Dysmicoccus brevipes*. (Photo: California Department of Food & Agriculture)

Pineapple fruits infested with Pink pineapple mealybug. (Photo: Samuel Kabi, Makerere University)

## Background

In the field, infestation appears as white powdery mealybug colonies on the lower stem and roots of pineapple plants, just above ground level; less commonly found feeding on the leaves, fruit and blossom cups. Roots are sometimes attacked. Adult female rotund and broadly oval, with pinkish or pink-orange body contents, and the surface covered in a layer of powdery white wax. The mealybugs reproduce parthenogenetically (without fertilization); the eggs hatch within the adult female and she births live, fully-formed larvae. Dispersal over short distances is by the first instar-crawlers walking. Crawlers may be dispersed passively by wind and animals. Dispersal over longer distances occurs by trade in consignments of infested plant material and fruit.

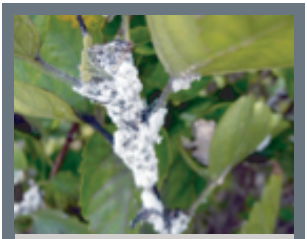
## Management

- Avoid movement of plant material between farms or regions to limit introduction and spread of the mealybug. Also enforce strict quarantine measures for importation of infested fruits or plant material.
- Use clean planting material to limit introduction of the mealybug onto the farm. Disinfect pineapple crowns, and slips used for new plantings need to be dipped or fumigated before planting.
- Heat treatment of the crowns in a water bath at 50°C will reduce the spread of *Pineapple mealybug wilt-associated virus* and also kill the insects.
- Observe general orchard hygiene by removing and destroying infested plants, plant residues and weeds.
- Keep field borders free from weeds that may harbour mealybugs and ants.
- Destroy ant colonies in the orchard - this increases the activity of natural enemies and reduces the spread of the mealybug.
- Conserve natural enemies e.g. ladybird beetles and parasitic wasps that help control populations of the mealybug, by avoiding the use of chemical pesticides
- Use neem extracts to control this insect; include a wetting agent in the mix to help penetrate the mealybugs' waxy coating.

## Pink hibiscus mealybug, *Maconellicoccus hirsutus*

### Recognise the problem

The pink hibiscus mealybug, *Maconellicoccus hirsutus,* is a serious pest of many plants in tropical and sub-tropical regions. It is polyphagous, feeding on hosts from 76 families including crops like asparagus, beans, beets, cabbage, peanuts, pigeon pea, cucumber, lettuce, pepper, pumpkin, and tomato; forest trees; and many ornamental plants. The mealybug feeds on the soft tissues and injects toxic saliva that causes stunting and contortion of leaves. This results in shoot tips developing a bushy/bunchy appearance; buds may not flower and stems may twist; fruit may also be deformed. The mealybugs feed on plant sap and expel sugary honeydew, fouling plant surfaces and developing black sooty mould. The mould blocks light and air from the leaves, reducing gaseous exchange and photosynthesis and weakening plant growth. On *Hibiscus* the mealybug infests young twigs, causing shortening of the internodes, thickened twigs and deformed leaves. On cotton, growing points are attacked, causing bunchy growth, restriction of boll opening and honeydew fouling of the lint, resulting in yield reduction. In grapevines, sprouts after pruning are infested, causing heavily infested bunches to shrivel and drop fruit. In peanut, the mealybug can feed on the underground parts (roots, pods, and pegs), resulting in stunted growth and poorly developed pods.



Pink hibiscus mealybug infestation on hibiscus (Credit: Florida Division of Plant Industry , Florida Department of Agriculture and Consumer Services, Bugwood.org)

Different life stages of Pink hibiscus mealybug (Credits: Jeffrey W. Lotz, Florida Department of Agriculture and Consumer Services, Bugwood.org)

Freshly-laid eggs of the pink hibiscus mealybug (Credits: Marshall Johnson, Department of Entomology, University of Hawaii)

### Background

Adult pink hibiscus mealybugs are small (about 3 mm long) and pink and are covered with a powdery white wax secretion. When adults are crushed their body fluids are bright pink. Adult males are smaller than females, reddish brown and have one pair of wings. The female dies shortly after depositing up to 600 eggs. With a life cycle of about 23-30 days and a high reproductive rate, the pest has up to 15 generations annually, so it can develop high populations quickly. The eggs overwinter in bark crevices, leaf scars, under bark, in the soil, on tree boles, and inside clusters of fruit or crumpled leaves. Natural dispersal happens when crawlers walk from one infested plant to the next, or are passively carried by wind, passing animals or people, or on agricultural equipment. Long-distance dispersal happens through transport/transfer of infested plant material from one region to another.

### Management

- Host-plant resistance - use mealybug-tolerant cultivars or varieties.
- Cut off infested stems or branches and destroy them by burning or burial 50 cm deep.
- Thoroughly clean equipment and check clothing items to prevent the transfer of the pest to new locations.
- Use high pressure water-jets to dislodge and kill mealybugs.
- Prevent the movement of ants and destroy ant colonies, as ants protect the mealybugs from their natural enemies and also help to spread the infestation.
- Conserve natural enemies like ladybirds, lacewings etc. by avoiding pesticide sprays and practising crop/plant diversity within the farm. Ladybirds have been used successfully against this pest. The ladybird *Cryptolaemus montrouzieri* is available commercially in Kenya as Cryptobug-L.
- Practice an integrated pest management regime involving pesticide use (as a last resort) if the mealybug populations reach a high level.
- Use botanical pesticides e.g. neem that have low impact on natural enemies, the environment and human health.
- Use commercial horticultural oils, which have impact on natural enemies than conventional pesticides.

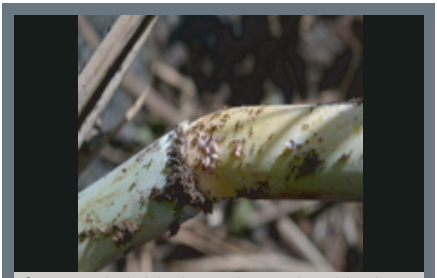
## Pink sugarcane mealybug, *Saccharicoccus sacchari*

### Recognise the problem

The pink sugar cane mealybug is present in every cane-growing country. It is a relatively minor pest of sugarcane but heavy infestations weaken the plants. Other host-plants attacked are mainly large grasses. The mealybugs suck phloem sap and eliminate sugary honeydew, which often attracts ants to feed on it. Damage results from depletion of the plant sap, depriving plants of essential nutrients which may lead to stunting, yellowing and thin canes. The honeydew produced provides a medium for sooty mould growth, fouling the leaves and impairing photosynthesis, resulting in reduced growth, sap sugar content and juice weight, and stunting or even death of young shoots, impacting cane quality and market value. Significant quantities of honeydew are produced by the mealybugs at certain times of the year, especially on cane varieties to which the trash adheres tightly; such mealybug infestations can cause processing difficulties during sugar manufacture. The pest may also transmit plant virus diseases.

Ants attending the mealybugs for their honeydew help to disperse the young crawlers to new feeding sites and protect the mealybugs from attack by natural enemies. This facilitates build-up of mealybug numbers, turning them from minor to major pests. Natural enemies play an important role in keeping the populations of sugarcane mealybug in check.

The mealybug population level and life cycle are greatly influenced by agricultural practices. Mealybugs that survive burning and harvesting of the cane move underground, often aided by attendant ants, and colonise cane tissue (including roots); later they emerge to re-establish aerial colonies once new storage tissue is formed above ground. Infestation of re-planted fields is often due to carry-over of mealybugs on the roots and stubble of the previous crop.



Sugarcane with a leaf sheath stripped away to show adult pink sugarcane mealybugs on the stem being tended to by ants in Kwale County, Kenya (Credits: Fernadis Makale, CABI)

Carton covering made by ants attending an infestation of pink sugarcane mealybug inside a sugarcane leaf sheath. (Credits: Fernadis Makale, CABI)

### Background

Colonies of pink sugarcane mealybug are usually found on the stems beneath leaf sheaths, but can also occur on the underground stems. Adults are soft, oval, wrinkled, wingless and up to 5 mm in length, pale pink and covered with white powdery wax. The mealybugs are able to survive harvests on the underground parts of the plant. Crawlers reappear and establish above ground once new storage tissues are formed, with infestation beginning beneath leaf sheaths. At or before egg-laying commences the females withdraw their mouthparts from the plant, making them immune to systemic insecticides, so a single pesticide application is ineffective against this pest. Local dispersal occurs through crawler locomotion, transfer by the attendant ants or passive dispersal on the wind; over longer distances the mealybugs are dispersed through transport by humans of infested fresh canes from one region to another.

### Management

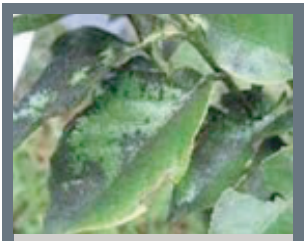
- Practice crop rotation with different crop species to avoid mealybug carry-over between crops, in the ground or on residues after harvest.
- Observe good general hygiene by removing plant residues and weeds (especially grasses) from the field.
- Before planting, select lines that are resistant to the pest; tight-threshing varieties are more prone to mealybug attack.
- Inspect planting material and destroy any mealybugs found on the cuttings/stalks before planting.
- Destroy ant colonies nearby, as they spread the mealybugs and also protect them from the activity of natural enemies.
- Conserve natural enemies e.g. ladybird birds, parasitic wasps by avoiding use of broad-spectrum insecticides, reducing dust in the field, practicing crop diversity etc.
- Clean equipment carefully before moving from one farm to the next.
- Use systemic pesticides (last resort).

## Coffee mealybug, *Planococcus kenyae*

### Recognise the problem

The coffee mealybug, *P. kenyae,* occurs only in the Afrotropical region and is believed to be indigenous to Uganda. After its introduction to Kenya in the 1920s, it became a pest on important crops like coffee. *Planococcus kenyae* has been recorded from host-plants in 12 genera belonging to 10 families. Important hosts include coffee, passion fruit, pigeon pea, yams, sugarcane, sweet potato, *Annona,* citrus, cocoa and guava. The mealybugs feed on phloem sap, depleting the plant's water and nutrient levels and causing defoliation, branch dieback and crop losses of up to 10%. The sugary honeydew eliminated provides a good medium for the development of sooty mould, which covers plant and nearby surfaces, blocking light and air from the leaves and impairing photosynthesis. Ants attend the mealybugs to feed on the honeydew. They defend the mealybugs from their natural enemies, making the pest problem worse. In the absence of ants, *P. kenyae* breeds more slowly and numerous predators keep the species under control. Coffee mealybug is a vector of several isolates of *Cocoa swollen shoot virus* disease. With the introduction of biocontrol agents to Kenya from Uganda the populations of this pest have been largely controlled.

Infestation of *P. kenyae* in clusters of coffee berries (Photo: Rob Reeder, CABI)



Sooty mould on coffee leaves (Photo: FAO, Asia)

Oval adult females of the coffee mealybug (Photo: Rob Reeder, CABI)

### Background

In the field, *P. kenyae* forms conspicuous white colonies between clusters of berries, flower buds or apical shoots, almost always attended by ants; spots of transparent honeydew and patches of dark sooty mould occur on the upper leaf surfaces. The adult female is oval, somewhat flattened, and about 2.5mm long and 1.5mm wide. Reproduction is sexual and she produces 50-200 eggs that are not enclosed in an ovisac. The eggs hatch in 2-3 days. The first instars crawl a short distance, usually upwards, until they find a suitable place to feed. Crawlers are responsible for local dispersal within plants, or between neighbouring plants if the canopies are touching. The mealybugs also are carried from place to place over short distances by the attendant ants. Long-distance spread occurs due to movement of infested plant material by humans.

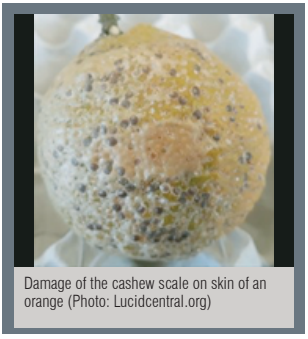
### Management

- Avoid the movement of planting material from infested areas to other areas.
- Check the orchard regularly to detect presence of the mealybugs early.
- Cut off infested plant parts and destroy them by burning, or burial 50 cm deep.
- Prevent pest spread by good orchard hygiene; remove and bury/burn prunings and crop residues.
- Remove weeds/alternate host plants like *Hibiscus*, etc. in and near the orchard.
- Prevent the movement of ants with a sticky band (e.g. Tanglefoot) around the tree trunk, and destroy existing ant colonies with boiling water or insecticides. Chemicals presently being used in Kenya against the attendant ants include Supracide, Chlorpyrifos and Rhodocide.
- Clean farm equipment before moving it to another orchard with an uninfested crop.
- There are biocontrol agents against this pest in Kenya. Encourage the build-up of natural enemies like ladybirds by reducing and localising pesticide sprays, and practising crop/plant diversity within the farm.
- Use a strong jet of water to dislodge and kill mealybugs.
- Spot-treat colonies with a soap solution made by dissolving a finger-sized piece of bar soap in 20 litres of water; or use botanical pesticides like neem extract, or a horticultural oil emulsion, that have low impact on natural enemies, the environment and human health.
- For heavy infestations, spot-treat with synthetic pesticides as a last resort.
- Implement an integrated approach against this pest combining cultural, biological, physical and chemical (last resort) strategies.

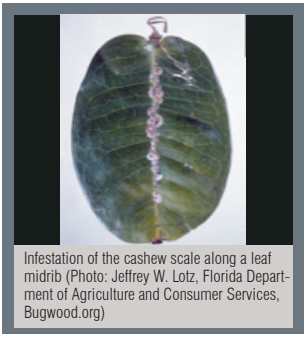
## Cashew scale, *Pseudaonidia trilobitiformis*

### Recognise the problem

*Pseudaonidia trilobitiformis* probably originated in southern Asia, but has spread considerably around the world and is sometimes a pest. It is highly polyphagous and has been recorded from host-plants in 107 genera belonging to 46 families. Important hosts include capsicum, chilli, citrus, coconut, papaya, coffee, mango, woody legumes, avocado, guava etc. It is an important pest of cashew, citrus and cocoa, especially in monoculture. The nymphs and adult females suck out cell contents from the foliage and inject toxic saliva, which causes chlorotic areas around the scales and can make leaves drop, weakening the tree and reducing productivity. Leaves are attacked more than flowers or fruits. The scale does not produce honeydew or cause sooty mould. Infestation may increase crop production costs as growers may need to treat to control scale populations. However, usually infestations on cashew are light due to natural control by parasites.



Damage of the cashew scale on skin of an orange (Photo: Lucidcentral.org)



Infestation of the cashew scale along a leaf midrib (Photo: Jeffrey W. Lotz, Florida Department of Agriculture and Consumer Services, Bugwood.org)

Adult *Pseudaonidia trilobitiformis* (Photo: California Department of Food & Agriculture)

### Background

In the field, cashew scale has a sub-circular pale- or yellow-brown scale cover, 3.0-4.5 mm in diameter, almost flat, with a yellow or red-brown central or sub-central area (a cast skin). The scales prefer feeding close to the midrib of the leaf, often on the upper surface. The immature male scale covers are smaller, elongate- oval but similar in colour to the female covers. Cashew scale reproduces sexually and has a high reproductive rate, producing large numbers within a short time. Crawlers are the main dispersal stage and walk to new parts of the plant, or are dispersed passively by wind or passing animals. Dispersal of sessile adults and eggs over longer distances occurs through human transport of infested plant material.

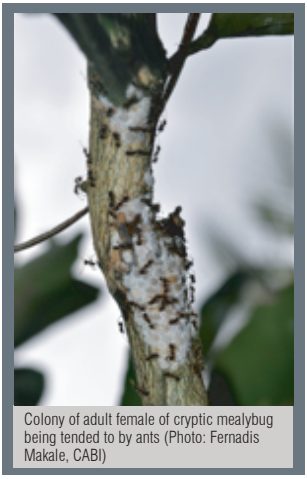
### Management

- Avoid the movement of planting material from infested areas to other areas.
- Carefully inspect planting material and reject and destroy any infested plants.
- Observe proper plant spacing to avoid plants touching each other – this may limit spread.
- Scout the orchard regularly to detect the presence of the scales early.
- Cut off infested plant parts and destroy them by burning, or burial 50 cm deep.
- Clean farm equipment before moving it to another orchard with an uninfested crop.
- Conserve natural enemies like ladybirds – avoid or minimise chemical spraying, dust etc and maintain crop/plant diversity within the farm. Control ants in the trees, as they attack the natural enemies of scales and can interfere with biological control.
- If necessary, spot treat affected trees, as opposed to the whole tree/farm.
- Use soap solution or botanical pesticides like neem extract, or commercial horticultural oil emulsion, that have low impact on natural enemies, the environment and human health.
- Implement an integrated approach against this pest by combining cultural, biological, physical and (only as a last resort) synthetic pesticides.

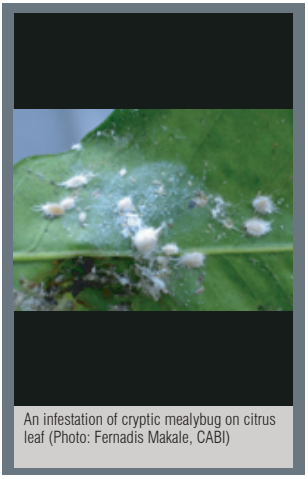
## Cryptic mealybug, *Pseudococcus cryptus*

### Recognise the problem

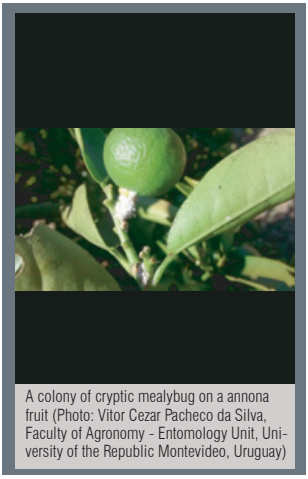
*Pseudococcus cryptus* is widely distributed in tropical and subtropical regions. It is polyphagous (recorded on 90 host plant species) but is a particularly serious pest of citrus. Other crops attacked are mango, avocado, coffee, banana, guava and palms. The mealybugs suck sap from the vascular tissue and eliminate copious sugary honeydew that fouls nearby surfaces including fruits and leaves. This provides a medium for the development of sooty mould fungi. The black sooty mould blocks light and air from the leaves and disrupts photosynthesis and gaseous exchange. Fruit and leaves may drop and tree growth and vigour are adversely affected, resulting in reduced citrus crop quantity, quality and value. The most serious damage is to young orchards of grapefruit, easy-peeling varieties and lemons. Natural enemies play an important role in reducing the pest population. However, indiscriminate pesticide usage against the mealybug and other pests can cause pest outbreaks because the natural enemies have been killed. Introduction of new citrus varieties/cultivars, most of which are susceptible, can also result in pest outbreaks.



Colony of adult female of cryptic mealybug being tended to by ants (Photo: Fernadis Makale, CABI)



An infestation of cryptic mealybug on citrus leaf (Photo: Fernadis Makale, CABI)



A colony of cryptic mealybug on a annona fruit (Photo: Vitor Cezar Pacheco da Silva, Faculty of Agronomy - Entomology Unit, University of the Republic Montevideo, Uruguay)

### Background

The mealybugs form large, conspicuous clusters on leaves and twigs. The adult female mealybug is about 2.5 mm long and the body contents are greenish yellow when crushed. The body is covered by white mealy wax and there are white wax pencils protruding from the margins, the longest pair at the rear end are divergent and may be as long as the body and divergent. Each female lays pale yellow eggs in a white ovisac under the abdomen. Up to 6 or 7 generations can be produced annually. Infestations occur on green aerial parts and sometimes even the roots. Dispersal is mainly by the hatchling crawlers over short distances, but all the female stages can walk, even from one tree to the next if the canopies touch. Long distance dispersal is by transport of infested plant material by humans.

### Management

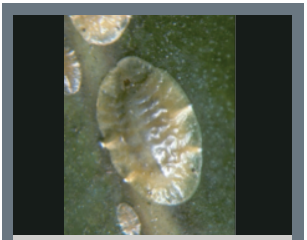
- Host-plant resistance - select crop varieties that are resistant to cryptic mealybug.
- Avoid the movement of planting material from infested areas to other areas.
- Monitor / scout regularly for early detection of the presence of the mealybug.
- Prune off infested crop parts and remove and burn, or bury them 50 cm deep.
- Use high pressure water jets to dislodge and kill mealybugs.
- Remove weeds / alternate host plants like *Hibiscus* etc. in or near the crop.
- Prevent the movement of ants with sticky bands on tree trunks, and destroy ant colonies with boiling water.
- Fumigate or wash picking sacks and boxes before re-use, to prevent the spread of citrus mealybug.
- Clean farm equipment before moving it to an uninfested crop or between farms.
- Encourage the build-up of natural enemies like ladybirds by reducing pesticide sprays and practising crop/plant diversity within the farm.
- Use botanical pesticides e.g. neem that have low impact on natural enemies, the environment and human health, to spot-treat infestations

# Green shield scale, *Pulvinaria psidii* and other species

## Recognise the problem

Green shield scale is a tropical species of unknown origin that has become widely distributed due to trade in infested plant material. It is polyphagous, feeding on host-plants in 141 genera belonging to 67 families; important hosts include avocado, citrus, coffee, ferns, flowering ginger, guava, pomegranate, pepper tree and rose apple. It has some preference for broad-leafed plants and is generally found on leaves and tender young stems. The scales suck up phloem sap and eliminate copious sugary honeydew, which coats nearby surfaces and gives rise to sooty mould growths. The sooty mould blocks light and air from the leaves, impairing photosynthesis. Sooty mould on fruit often makes it unsightly and unmarketable or of a lower grade; the fungus is difficult to wash off. Heavy infestations of *P. psidii* cause leaf yellowing, defoliation, reduction in fruit set and loss of plant vigour. The sweet honeydew is fed on by ants, bees and wasps, which may protect the scales from their natural enemies.

Adult female *Pulvinaria psidii* with ovisac (Photo: Chris Mallory, Bugguide.net)



Adult *Pulvinaria psidii* (Photo: United States National Collection of Scale Insects Photographs, Bugwood.org)

Young stage of *Pulvinaria psidii* (Photo: California Department of Food & Agriculture)

## Background

*Pulvinaria psidii* usually feeds on leaf undersides and stems. The adult female is wingless, ovoid, green to yellow, and becomes thinly covered with a white powdery wax; a short ovisac of white wax threads is produced from under the abdomen, into which about 200 eggs are laid. Reproduction is asexual; males are not known. The first-instar crawlers walk short distances and settle on leaf undersides; alternatively, crawlers can be passively dispersed by wind, on farm equipment and passing animals, and by attendant ants. Human transport of infested plant material can carry the insects over longer distances.

## Management

- Inspect plant material thoroughly before planting and destroy any scales.
- Monitor the plants immediately after transplanting and then on a weekly basis. Look on the leaf undersides (especially along the main veins) and green wood near the tips of shoots for ovoid, green to yellow scales, sometimes covered with white powdery wax.
- Prune off old branches and leaves to enhance aeration through the canopy, and prune low branches and remove weeds to stop ants reaching the leaves and fruits. Destroy any infested prunings by burning or burial 50 cm deep.
- Controlling attendant ant populations helps to reduce levels of this pest. Ant nests in the soil can be killed with boiling water. Nests in the foliage can be pruned off into a bucket of boiling water. To prevent ants climbing a tree to attend the scales and drive off predators and parasitoids, apply with a brush to the stem, 1 foot above the base, a 15 cm-wide band of one of the following:
    1. A sticky non-drying glue (e.g. "Tanglefoot").
    2. a deltamethrin-based product such as Decis 2.5 EC, Atom 2.5EC etc. at the rate of 10-15ml/20L of water mixed with 15g of Methylene blue, which acts as a marker.
- Encourage/conserve natural enemies e.g. ladybird beetles like *Cryptolaemus montrouzieri* and parasitoid wasps by sparsely planting shade trees such as species of *Grevillea, Leucaena* or *Macadamia.*
- To achieve management of this scale, practice an integrated pest management approach area-wide, to avoid re-infestation.
- Heavily scale-infested trees can be spot-treated with pesticides such as:
    - Soap solution (potassium soaps). Add 10-15 tablespoons-full of liquid soap to 20 L of water.
    - Botanical pesticides like neem extract or garlic oil or mineral oil emulsions at 200 ml per 20 L of water.

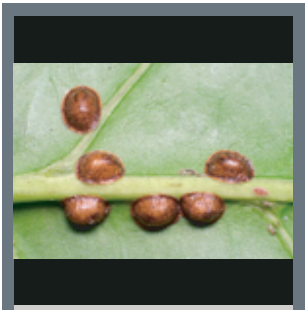
**Notes:**

- Sprays are effective on the vulnerable immature stages but control of the waxy adult females is difficult.
- Dead adults remain firmly attached to the plant, which may give a false impression of the size of the infestation.

## Hemispherical scale, *Saissetia coffeae*

### Recognise the problem

Hemispherical scale is a tropical species of unknown origin that has been spread widely in the trade in live plants. It is highly polyphagous, feeding on host-plants in 294 genera belonging to 107 families. Important host-plants of *S. coffeae* include coffee, tea, citrus, guava, mango, ornamental shrubs, greenhouse plants and ferns. The scales suck up phloem sap and eliminate copious sugary honeydew, which coats nearby surfaces and gives rise to sooty mould growths. The sooty mould blocks light and air from the leaves, impairing photosynthesis. Heavy infestations cause loss of plant vigour, spots on the foliage due to toxins in the insects' saliva, deformation of infested plant parts, loss of leaves, stunted plant growth, and even death of the plant. Damage to mature plants is usually slight but can be severe in young plants and seedlings, which may suffer die-back or even die. Hemispherical scale may be attended by ants, which feed on the sweet honeydew and protect the scales from their natural enemies.



Adult *Saissetia coffeae* along the midrib of a leaf (Photo: Koppert)

Infestation of the hemispherical scale, *Saissetia coffeae* on coffee; sooty mould damage also present (Photo: Scot Nelson , Flickr)

Adult female of *Saissetia coffeae.* (Photo: California Department of Food & Agriculture)

### Background

In the field, live adult female hemispherical scales are easily seen as shiny brown domes on stems and leaf undersides, close to the major veins. The mature adult female is 2-3 mm long, with the red-brown dorsum highly convex, hard and shiny. The immature female is flat, yellow-brown, with three dorsal ridges resembling the letter H; these ridges disappear at maturity. The scale reproduces by parthenogenesis (without fertilization). Each female lays about 500 eggs in a cavity under her body. After hatching, the first-instar crawlers walk about to find a place to feed. Dispersal is also aided by carriage on the wind, animals including human beings, as well as human transport of infested plants. The development time of the scale is dependent on temperature. At 30°C the pest completes a generation in about 8 weeks and is able to produce 2-3 generations per year.

### Management

- Use clean planting material. Check seedlings for infestation before planting.
- Regularly monitor the plants to detect the scale early.
- Cut off infested plant parts and destroy them by burning, or burial 50 cm deep, to avoid spread in the orchard.
- For trees, prune low branches and remove weeds to stop ants reaching the leaves and fruits. Keep canopies separate to prevent cross-in fection.
- Remove alternate hosts from near the crop. These plants serve as re-infestation sources.
- Apply mulch, manure or synthetic fertilizers in moderation to assist/boost plant vigour. Heavy use of fertiliser may result in scale numbers multiplying.
- Avoid movement of plant material from infested areas.
- Destroy nearby ant nests with boiling water, without damaging the plants infested with the scale insect; without ants protecting the scale insects, parasitoids and predators will bring them under natural control.
- Encourage the build-up of natural enemies like ladybirds and parasitic wasps by reducing and localising pesticide sprays, and practising crop/plant diversity within the farm.
- Treat with a soap solution (made by dissolving a finger-sized piece of bar soap in 20 litres of water), or neem extract or garlic oil, or a horticultural oil emulsion, that have low impact on natural enemies, the environment and human health.

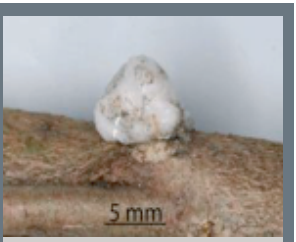
# Soft wax scales, *Ceroplastes* species

## Recognise the problem

Many *Ceroplastes* species are polyphagous; they attack a large number of woody plants including citrus, coffee, quince, persimmon, mango, guava and pear. Soft wax scales mostly attack leaf midribs or petioles and the branches and stems of host plants. The scales suck phloem sap and eliminate copious sugary honeydew, which fouls nearby surfaces and gives rise to black sooty mould growths. The mould blocks light and air from the leaves, impairing gas exchange and photosynthesis, reducing plant vigour, growth and yield. Heavy infestations may cause wilting and leaf drop due to sap depletion. Ants attend the scales because they feed on the sweet honeydew, and they defend the scales from attack by natural enemies, making the pest problem worse. Soft scales are dispersed by the crawlers actively walking, or passively by the wind or passing animals. Movement of infested plants in trade can transport soft wax scales over longer distances.

Worker ants feeding on honeydew from Soft wax scales on *Gardenia* sp. (Rubiaceae). (Photo: Nicholas A. Martin, Plant & Food Research)

Adult female Soft wax scales, *Ceroplastes rusci.* (Photo California Department of Food & Agriculture)




Adult female Soft wax scale on stem of *Syzygium* sp. (Myrtaceae). (Photo: Nicholas A. Martin, Plant & Food Research)

## Background

In life, adult female soft wax scales are 3.0-5.5 mm long and 1.5-3.0 mm wide, but with the thick wax coating they appear larger. The thick layer of white or grey wax forms a strongly convex and irregular shape and is often soft under pressure. Under the wax, the female has a strongly sclerotized anal process. The scales usually settle along leaf midribs or petioles; young nymphs form small white wax plates in a star-like rosette with short 'arms'. Subsequent developmental stages become completely coated in wax. Old females may become grey-white with sooty mould fungus. There is usually one generation per year but in optimal conditions they may produce a second one.

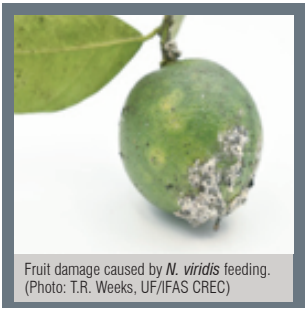
## Management

- Limit movement of suspect plant materials between orchards, farms and regions.
- Select seedlings for planting that are free from scale insects. Plant them widely spaced.
- Prune trees to prevent their canopies touching; otherwise the crawlers can walk from one tree to another.
- Infested plant parts should be pruned off, and prunings and crop residues should be destroyed by burning or burial 50 cm deep.
- Clean equipment thoroughly to remove scale insects and minimise spread, before using it in uninfested parts of the field.
- Wash infested plants with a high pressure water jet to dislodge scales and drown crawlers; this can reduce the severity of the infestation and sooty mould damage.
- Conserve natural predators such as ladybirds and green lacewings by planting attractive flowering plants on the ridge or border of the orchard.
- Reduce pesticide use to spot treatments only; avoid the use of persistent and broad-spectrum pesticides.
- Spray with a narrow-range horticultural oil emulsion (follow application instructions on the bottle). This is less disruptive to natural enemies and bees than many other insecticides.
- Use botanical pesticides e.g. neem that have low impact on natural enemies, the environment and human health.
- Control large populations of ants if they are seen tending the scale, since they can defend scales from attack by natural enemies. Ant nests in the soil can be killed with boiling water. Nests in the foliage can be pruned off into a bucket of boiling water.
- Band the trunks of coffee trees with a sticky non-drying glue (e.g., "Tanglefoot"), to prevent ants from climbing the trunk to attend the scales.
- To prevent ants climbing a tree, apply with a brush to the stem, 1 foot above the base, a 15 cm-wide band of a deltamethrin-based product such as Decis 2.5 EC, Atom 2.5EC etc. at the rate of 10-15ml/20L of water mixed with 15g of Methylene blue, which acts as a marker.

## Spherical mealybug, *Nipaecoccus viridis*

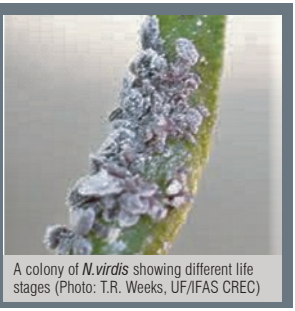
### Recognise the problem

*Nipaecoccus viridis* is quite widespread in the tropics and subtropics, and can cause considerable crop damage. It is polyphagous, feeding on mostly woody plants in 18 families, including food, forage, fibre crops like cotton, and ornamental plants. Other important crops attacked by this pest include citrus, coffee, soybean, mango, tamarind, pomegranate and grapevines. The mealybugs suck out phloem sap, depleting the host's water and nutrient levels. Copious sugary honeydew is eliminated, which fouls nearby surfaces and gives rise to sooty mould growths. This blocks light and air from the leaves, impairing gaseous exchange, photosynthesis and productivity. The type of injury caused is related to the pest's pattern of colonising the host plant, and the specific susceptibility of the cultivar. On citrus the mealybug can be a major pest, causing curling and dwarfing of young growth; chronic infestation results in deterioration of the crown, yellowing, wilting and eventually death. Young fruits may drop and affected fruits develop unsightly lumps and corky scars around where the colony feeds, distorting the shape of the fruit. Where the insects feed, irregular watery green spots form on the peel of ripe fruits, rendering them unmarketable. In addition, fruit moths are often associated with mealybug-infested fruit, further compounding the injury. The honeydew eliminated by the mealybugs attracts ants that feed on it. In return they defend the mealybugs from attack by their natural enemies, and remove honeydew.



Fruit damage caused by ***N. viridis*** feeding. (Photo: T.R. Weeks, UF/IFAS CREC)

Damage to citrus fruit caused by ***N. viridis*** (Photo: T.R. Weeks, UF/IFAS CREC)



A colony of ***N.virdis*** showing different life stages (Photo: T.R. Weeks, UF/IFAS CREC)

### Background

The mealybug colonizes fast-growing tissues like new growth, new branches, and fruit. Infestations also occur at branch junctions, underneath calyx sepals and fruit buttons. The adult female is oval, 2.5-4 mm long and 1.5-3 mm wide, becomes very rotund with age, and is coated with a thick layer of mealy wax that is white initially but may turn pale yellow in old specimens. The body contents are dark green / purple / dark brown purple. A large hemispherical ovisac is formed under the abdomen, composed of white loose wax filaments, and may contain several hundred violet eggs. The adult male (1.3-2.5 mm long) is brown-purple with one pair of well-developed forewings. Dispersal is by the small crawlers walking, or being passively carried by people, animals, farm tools (like pruning shears), farm equipment (trucks, sprayers, tractors), the wind, and human transport of infested material. Some of the mealybugs are even carried by ants to new hosts.

### Management

- Host-plant resistance - plant crop varieties that are resistant to the spherical mealybug.
- Monitor / scout regularly to detect the presence of the mealybug early.
- Observe good orchard hygiene – cut off infested plant parts and destroy prunings and crop residues by burning or burial 50 cm deep.
- Prevent the movement of ants and destroy ant colonies nearby.
- Thoroughly clean farm equipment before moving it to an uninfested crop or between farms
- Avoid the movement of planting material from infested areas to other areas.
- Use high-pressure water jets to dislodge and kill mealybugs.
- Encourage the build-up of natural enemies like ladybirds, earwigs, parasitic wasps etc. by reducing pesticide sprays and maintaining crop/plant diversity within the farm.
- Thoroughly wash picking sacks and boxes before re-use, to prevent the spread of the mealybug.
- Use botanical pesticides (e.g. neem) that have low impact on natural enemies, the environment and human health.
- If using synthetic pesticides (last resort), ensure that you:
    a. Follow the product label instructions on rate, PHI, storage etc.
    b. Practice spot application
    c. Include a wetting agent / sticker to help the spray penetrate the waxy covering
    d. Spray when the crawlers are active, as they are easiest to kill.

## Striped mealybug, *Ferrisia virgata*

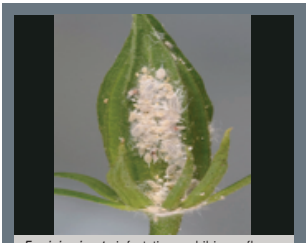
### Recognise the problem

*Ferrisia virgata* is a highly polyphagous mealybug that can occur on host-plants belonging to over 203 genera in 77 families. It can damage many crops, particularly tropical fruits, nuts and spices and field crops like soybean and tomato. Its polyphagy has facilitated the mealybugs' spread by human transport of infested plants. *Ferrisia virgata* is now established in all the subtropical and tropical zoogeographic regions. With the increase in international trade in fresh plant material, mealybug spreading is likely to continue, facilitated by their small size and cryptic habits that make them difficult to detect and identify at plant quarantine inspection.

Striped mealybugs suck phloem sap, depleting the plant nutrient level, reducing plant growth and causing leaf discoloration and leaf and fruit drop. As they feed the mealybugs eliminate copious sugary honeydew, which is an excellent medium for sooty mould growth. This fungus forms a dark film on the plant surface, blocking light and air from the leaves and impairing photosynthesis. Heavy infestations result in unsightly white and black sticky masses, reducing the value and marketability of fruits. The honeydew also attracts ants that feed on it. Attendant ants protect the mealybugs from attack by their natural enemies and carry mealybugs to new feeding locations, so spreading them. *Ferrisia virgata* is known to vector plant pathogens. It has been reported to transmit *Cocoa swollen shoot virus, Citrus tristeza virus,* and *Piper yellow mottle virus.*

Adult and immature female *Ferrisia virgata* on croton. (Photo: Ariane McCorquodale, University of Florida)

*Ferrisia virgata* (Photo: ICAR-NBAIR, Bangalore, India)



*Ferrisia virgata* infestation on hibiscus flower bud. (Photo: Lyle J. Buss, University of Florida)

### Background

In life, adult female striped mealybugs are oval, up to 5 mm long, greyish-yellow and coated with a thin layer of powdery white wax apart from two longitudinal, sub-median, interrupted dark stripes of bare cuticle on the dorsum - hence the common name 'striped mealybug'. Additional identifying features of the striped mealybug are the two robust posterior white wax tails, each usually at least half as long as the body; also, the presence of crystalline, hair-like rods extending laterally from the body, and the absence of an ovisac (egg sac). The adult male, if present, has long antennae, six well-developed legs, one pair of simple wings, no mouthparts, and a pair of long white wax filaments at the posterior end.

### Management

- Carefully inspect purchased planting material to avoid spreading mealybugs.
- Regularly examine susceptible plants for mealybugs or masses of cottony wax.
- Isolate infested plants or immediately prune off infested parts, to prevent spread.
- Prune off infested leaves and stems; destroy them by burning or burial 50 cm deep.
- Observe good crop hygiene - remove and bury or burn crop residues.
- Remove weeds/alternate host plants like *Hibiscus*, etc. in and near the crop.
- Avoid the movement of planting material from infested areas to uninfested areas.
- Prevent the movement of ants and destroy already existing ant colonies.
- Clean farm equipment thoroughly before moving it to an uninfected crop.
- Use a strong jet of water to dislodge and kill mealybugs.
- Encourage the build-up of natural enemies like ladybirds by reducing pesticide sprays and practising crop/plant diversity within the farm.
- Use botanical pesticides e.g. neem that have a low impact on natural enemies, the environment and human health.

Design and layout by Simon Ndonye; info@zolicreation.net