MEALYBUGS

Planococcus citri (Risso) Citrus mealybug
Paracoccus burnerae (Brain) Oleander mealybug
Nipaecoccus viridis (Newstead) Karoo thorn mealybug
Delottococcus aberiae (De Lotto)
Pseudococcus longispinus (Targioni-Tozzetti) Longtailed mealybug
Pseudococcus calceolariae (Maskell) Citrophilous mealybug
Ferrisia virgata (Cockerell) Striped mealybug

1 PEST PROFILE

1.1 Distribution and status

Various mealybug species attack citrus. The most important, in terms of conventional pest status, are considered to be the citrus mealybug, *Planococcus citri* (Risso), the oleander mealybug, *Paracoccus burnerae* (Brain) and the longtailed mealybug *Pseudococcus longispinus* (Targioni-Tozzetti). The Karoo thorn mealybug, *Nipaecoccus viridis* (Newstead) can also occasionally be problematic on young trees. *Delottococcus aberiae* (De Lotto) is a rare species that has been recorded from KwaZulu-Natal, Swaziland and the Limpopo Province. *Pseudococcus longispinus* (Targioni-Tozzetti) has occasionally been recorded as the dominant species in orchards in the Northern and Eastern Cape, the Boland region of the Western Cape and parts of the highveld in Zimbabwe. *Pseudoccocus calceolariae* (Maskell), the citrophilous mealybug, may also be abundant in the Boland region of the Western Cape Province. *Ferrisia virgata* (Cockerell) is rarely encountered and not of economic importance. Some mealybugs are phytosanitary pests for many markets and their economic importance in terms of phytosanitary considerations may be quite different from their conventional pest status.

Mealybugs occur sporadically in all production areas, but have historically been regularly problematic in Swaziland, KwaZulu-Natal and the Eastern Cape. The status of the pest increased in most regions since the early to mid 1990s. This increase in status is attributed to movement away from broad-spectrum full cover spray treatments in spring, to disruption of biocontrol through the use of some thripicides and the regular use of some Insect Growth Regulators (IGRs) for the control of red scale.

1.2 Description

Adult females of citrus mealybug are 3 to 4 mm long. The body of the female is covered with a mealy, white wax layer. This layer does not hide the body shape as in the case of waxy scale, and the body segments can be seen. The females of the citrus mealybug have a faint stripe running along the length of the dorsal body surface where a thinner wax layer permits the underlying body colour (yellowish to yellowish-brown) to become visible. A cottony white egg sac is formed beneath and behind the adult females. The winged males are considerably smaller than the females and are seldom seen in orchards. They are also characterised by the presence of two long, white anal filaments. Eggs of citrus mealybug are yellow and covered by a white, woolly egg sac that does not have a specific shape. Newly hatched nymphs (crawlers) are yellow, mobile and disperse to food sources. The female has three nymphal stages which generally resemble the shape of the adult.

The adult female oleander mealybug is similar in appearance to the citrus mealybug. It is slightly smaller (2 to 3 mm long), does not have the longitudinal stripe, the body fluids are grey and the waxy filaments around the rear of the body are longer than in the citrus mealybug, particularly the anal pair. The early life stages are darker than the citrus mealybug. *Delottococcus aberiae* closely resembles oleander mealybug.

The adult female Karoo thorn mealybug is approximately 4 mm long, has dark purple body fluids and the body is largely hidden beneath a waxy egg sac which is globular with a finely striated surface and the threads can be drawn out into long strands. The eggs and immature stages are distinctly purple.

The adult female longtailed mealybug is approximately 3 mm long and is easily recognisable by the greatly elongated anal filaments which are often longer than the body. The longtailed mealybug does not produce a distinct egg sac and produces live offspring

(crawlers).

The adult female citrophilous mealybug is relatively large (3 to 5 mm). Body fluids are a brownish amber colour and a distinct egg sac is formed.

The adult female striped mealybug is approximately 2 to 4mm long. Numerous long, thin, hair-like filaments extend from the body. Distinct inter-segmental body divisions are visible in addition to two faint stripes along the length of the body. Egg sacs are formed with the hair-like filaments.

1.3 Infestation sites on the tree

Mealybugs overwinter primarily in cracks and crevices in the trunk and main branches of citrus trees. Leaves that have been malformed and curled as a result of thrips, citrus leafminer or mealybug also serve as winter habitats. During spring and early summer the nymphs, which are positively phototactic, move to the foliage canopy and infest young growth and fruitlets. A preferred feeding and breeding site is the area under the calyx of fruitlets. In the case of heavy infestations, populations spread out from under the calyx to form colonies around the calyx and also between touching fruit. Mealybugs can often be found in the navel openings of navel oranges on which they are especially problematic. In addition to infesting fruit, oleander mealybug thrives on leaves and to a lesser extent also on the wood.

Young life stages of Karoo thorn mealybug form dense colonies on twigs, especially around the calyxes and on young fruitlets. Older life stages form clusters on the wood where they overwinter. This mealybug is seldom associated with mature fruit.

1.4 Damage

1.4.1 Symptoms

Direct damage is done to the crop as a result of mealybug activity. Fruitlets subjected to heavy infestations turn yellow and drop. Easy peeler cultivars are particularly sensitive to mealybug infestation and a fruit infested with only one or two insects may fall. Infested fruit can also be malformed without dropping. This type of damage is caused by mealybug feeding under the calyx which results in the formation of dents and lumpy shoulders in the fruit tissue around the calyx. This damage can be particularly severe in the case of infestations by the Karoo thorn mealybug. Fruit damage usually occurs between petal fall and the time fruit attain approximately golf ball size.
Thrips scarring of fruit around the calyx is accentuated on fruit which harbour a mealybug infestation below the calyx. In regions with cold winters, late season mealybug infestations on the cheeks of fruit, especially navels, readily lead to the formation of reddish blemishes on the peel (hyper-pigmentation or stippling). Persistence of a mealybug infestation on grapefruit after the end of January leads to the formation of intensely coloured bumps on the cheeks of fruit and irregular colouring due to sooty mould. The incidence of post harvest navel end *Alternaria* decay has been found to increase with mealybug infestation.

Apart from direct fruit damage, indirect damage can be caused by the sooty mould deposits that develop on the copious honeydew resulting from mealybug infestations. Refer to SOFT SCALES for more information on this topic.

Carob moth *Ectomyelois ceratoniae* (Zeller) attacks mealybug-infested grapefruit. The reddish larvae feed on mealybug and honeydew beneath the calyxes, between touching fruit and especially between leaves and fruit.

Young leaves infested with mealybugs become characteristically bent as a result of the insect's feeding activities at the main vein. Karoo thorn mealybug feeding on young twigs result in bulbous outgrowths and young trees may be stunted.

1.4.2 Seasonal occurrence

In the hotter regions, citrus and oleander mealybug populations have the potential to reach extremely high levels by mid-season (100% fruit infestation), even when infestations were barely discernable in early spring. Mealybugs present a serious threat to the crop during the first six weeks after petal fall. In the hotter areas, if they are absent during this period they are unlikely to become a threat

during the remainder of the season. Fruit is less susceptible to direct damage during mid-summer, although carob moth infestations occur in this period. Mealybug populations tend to only build up during mid- to late-summer in the Cape. The persistence of late-season infestations also poses a direct threat to the crop.

Karoo thorn mealybug infestations are usually patchily distributed through orchards and are seldom recurrent. When infestations of oleander and citrus mealybug come under biocontrol before the end of the season they often do not recur the following season. There are however, some orchards in which mealybug infestations recur repeatedly and the reasons for this persistence are unclear.

2 MANAGEMENT ASPECTS

2.1 Infestation/Damage assessment

2.1.1 Inspection

The persistence of live mealybug on fruit at the time of harvest should be determined to assist in evaluating the need for chemical intervention during the next spring period. This can be done by inspecting fruit on trees shortly before harvest, including inside fruit, or by sampling from the picking bins. It is important to distinguish between live and dead mealybug which can easily be done by squashing individuals to see whether they are dried out or not.

The tree framework and curled leaves must be inspected during winter for signs of live mealybug. Weekly inspection of new growth must be made from budburst to petal fall and thereafter weekly fruit inspection is required. It is necessary to look under the calyxes of young fruit for a meaningful evaluation.

Sticky ant bands often give an early warning of developing mealybug infestations because mealybugs congregate beneath these bands and are caught on the sticky surface. Likewise, the presence of ladybird predators is often easily recognisable by the larvae trapped on the sticky surface of ant bands.

2.1.2 Treatment threshold

Severe mid-season infestations often come under good biocontrol before the end of the season and no chemical intervention is required the next season. Although there are no established thresholds for late-season evaluations, an obvious and widespread infestation in excess of approximately 10% of fruit with live mealybug shortly before harvest, is an indication that chemical intervention will be required the following spring.

Obvious mealybug infestation (of trunks, branches and leaves) during winter, on the new flush in spring, or on flowers and fruitlets during blossom, indicates the need for chemical intervention to protect the young fruitlets. An infestation level in excess of approximately 5% at petal fall, or up to 20% six weeks after petal fall, indicates the need for immediate chemical intervention.

There is little benefit to be derived from chemical intervention between six weeks after petal fall and the end of January in the northern areas and the end of February in the Cape. However, if during this period, there is extensive development of mealybug colonies with egg sacs on the cheeks of early maturing cultivars, and there is no sign of biocontrol activity, chemical suppression of the population with a short-residual treatment can be valuable.

If there is no decrease in the infestation level, with an associated increase in biocontrol activity, by the end of January (N) or end of February (Cape), suppression with a short residual treatment is advisable on early maturing cultivars.

There is a particularly low tolerance for Karoo thorn mealybug during the early part of the season up to six weeks after petal fall, since extensive fruit damage can result. Any general infestation during this period warrants chemical intervention. Later in the season fruit are less likely to be attacked.

It is important to remember that mealybug cannot be controlled on a purely chemical basis. Even with the use of highly effective mealybug treatments, a considerable contribution from the biocontrol complex is required to avoid the development of damaging population levels.

It appears that the biocontrol complexes of oleander mealybug and longtailed mealybug, in particular, may not be as effective as that of citrus mealybug. Therefore, more conservative treatment thresholds can be used when either of these species are identified as the dominant species in a particular orchard.

Although the tolerance levels for mealybugs present on fruit at harvest are far lower when considering phytosanitary risk than with conventional pest considerations, there are no differences in Good Agricultural Practices and Treatment Thresholds pertaining to the control of mealybugs as a conventional pest or as a phytosanitary concern.

2.2 Control options

2.2.1 Biological

Mealybugs are in general attacked by an efficient biocontrol complex consisting of numerous hymenopteran parasitoids, predatory fly larvae, lacewings and ladybird beetles. If not disrupted with sprays, these complexes are capable of rapidly bringing severe infestations under complete control during mid- to late-season. These biocontrol agents are also found in the orchards in early spring, indicating that the biocontrol of mealybugs is also susceptible to chemical disruption from early-season sprays such as thripicides.

One of the two most abundant hymenopteran parasitoids is *Anagyrus* sp nr *pseudococci,* which is easily recognisable by being brownish in colour with distinctive white antennae with which they tap surfaces. The other is *Coccidoxenoides perminutus* which is not easily recognised as an adult because of its small size (1 mm). However, mealybug parasitised by this species form small oblong mummies which are easily discernible. *A*. sp nr *pseudococci* generally parasitizes third instar and adult mealybugs, whereas *C. perminutus* generally attacks second instar mealybugs. *Nephus* species ladybird beetles are common predators, but the larvae are often mistaken for mealybugs which they closely resemble. The adults are approximately 2 to 3 mm long and the body is mostly black with two or four small red or reddish brown spots.

Augmentative releases of biocontrol agents mass reared in insectaries have been shown to form a valuable control strategy. The coccinellid predator *Cryptolaemus montrouzieri* is effective in controlling heavy mealybug infestation levels at a release intensity of 1000 to 2000 beetles/ha, although *C. montrouzieri* has poor dispersal ability. The high cost of rearing this predator is an obstacle to its commercial utilisation. Augmentation of the parasitoid *C. perminutus* has been shown to be a cost effective control strategy for *Planococcus citri*. Research trials indicated that *C. perminutus* should be released at a rate of 100 000/ha per season, commencing in spring. However, commercial releases appear to generally be conducted at lower rates than this. Dispersal is fairly rapid and orchards adjacent to release sites should be colonised within 60 days. ***C. perminutus* augmentation is suitable as an alternative to preventative sprays for citrus mealybug control, but not as an alternative to corrective sprays when considered necessary in terms of the treatment thresholds.** Augmentation of *C. perminutus* is not recommended for mealybug species other than citrus mealybug. *C. perminutus* is approximately 100 times less fecund on oleander mealybug than on citrus mealybug.

Effective ant control is incomparably important in maximising the potential of the biocontrol complex. Even a very low level of ant activity in the tree can be significantly disruptive. The importance of this consideration is often overlooked and has traditionally been underestimated by producers. Ant presence on the floor of the orchard is considered to be beneficial, whereas, in terms of mealybug control, any discernable ant activity within the tree canopy should be viewed as highly problematic. Judicious selection of chemical treatments for other pests, particularly thrips and red scale, is also important.

2.2.2 Cultural

There are no cultural measures that can be used to prevent mealybug infestations. The removal of unwanted and dead twigs and branches from the inside of the tree will assist the penetration of spray treatments. The same applies to good pruning practices. Where trunk barriers are used to control ants, to aid the

biological control of the pest, tree canopies should be skirted and weeds controlled.

2.2.3 Plant protection products

Experiments have indicated that the most effective time for chemical suppression of mealybugs is in the spring period, especially shortly after commencement of the first crawler movement. The efficacy of sprays is greatly reduced once mealybug are established under the calyx. Apart from the calyx itself, the debris and sooty mould resulting from mealybug presence soon provides an effective seal against spray treatments. The same applies to infestations inside navel openings.
Where chemical suppression is required after the calyx touches the fruit, a short-residual treatment should be used to suppress the population. This gives the biocontrol complex a chance to provide subsequent control. If the biocontrol complex fails to respond to the residual infestation, follow- up treatments may be required.

The level of control achieved with mealybug sprays is largely influenced by application efficacy. The highest level of coverage is required for mealybug sprays relative to any other citrus pest and the addition of a wetting agent is advisable.

Even the timeous use of the most effective treatments presently available will not provide effective control for the remainder of the season, without the contribution from the biocontrol complex. It is therefore especially important for the management of mealybug infestations that the use of disruptive sprays for the control of other pests is avoided.

Experiments have indicated that a full cover spray of mevinphos, for the control of other pests as registered, will provide useful suppression. The registered dosage of Lannate may be inadequate.

A **trunk treatment** of Mospilan SL at 2.0 ml/m^2 canopy surface, applied between mid-October and mid-December, is registered for the control of mealybug. It must not be applied to green wood of younger trees. Repeated use of Confidor for the control of other pests as registered may contribute to the long-term suppression of mealybug populations.

The following **spray treatments** are registered for mealybug control but check residue restrictions before applying to fruit.

Product	Dosage/100 ℓ water
Applaud + light mineral oil[1] + wetter/sticker	30 g + 250-500 ml + 10 ml
Lannate SL	90 ml
Lannate SP	20 g
Selecron/Proton[2]	100 ml
Dursban WG	64 g
Chlorpyrifos EC	100 ml
Dursban WG + narrow range oil[1]	38 g + 500 ml
Folimat + narrow range oil[1]	50 ml + 1 ℓ
Parathion EC	125 ml
Parathion WP	300 g
Mospilan SP[3]	50 g[3]
Tokuthion	50 ml
Ultracide	150 ml

[1] Refer to Plant Protection Products under RED SCALE, for precautions when using oil.
[2] May be phytotoxic to grapefruit, mandarin types and mid-season cultivars.
[3] Registered at 40 g/100 ℓ water on nursery trees and on non-bearing transplants.