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# Integrated Pest Management for Citrus

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## 1 Introduction to Integrated Pest Management

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Learner Guide

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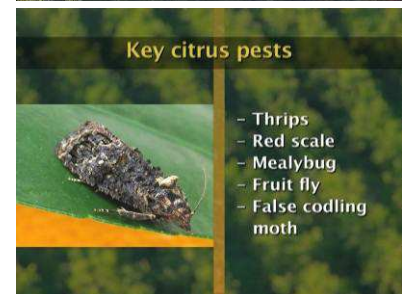
### *Second Edition*

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## Introduction

Citrus pest management is one of the most dynamic aspects of pre-harvest production of citrus fruit. There are dozens of different pests that can occur on citrus in Southern Africa, although there are only a few that occur and that require any form of control measure and these we would call key citrus pests. These would be pests such as:

- ❖ Citrus thrips
- ❖ California red scale
- ❖ Mealybug
- ❖ Fruit fly
- ❖ False codling moth



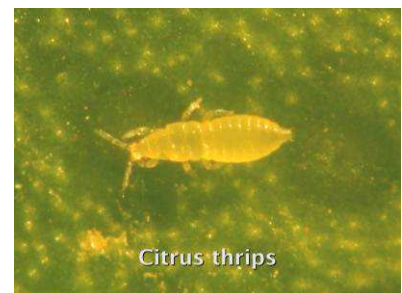
## Pest Categories

Pests can fall into a number of different categories. The first is **cosmetic** pests, which are pests which cause no harm to the actual quality of the fruit, but they blemish the fruit and make the fruit less marketable. An example of a cosmetic pest would be citrus thrips.

The second would be what we would call **production** pests or pests that influence the crop size of the orchard. An example of a production pest, a pest that affects the yield, would be bollworm, which could also be a cosmetic pest.

Another category of citrus pests is **phytosanitary** pests, which are endemic to the production area. This means they only occur in the production area, which could be Southern Africa or Africa, and they are pests that export markets don't want to get into their countries. This includes pests like fruit fly. Closely related to this category would be pests that cause pre- and postharvest waste problems. Fruit fly and false codling moth would fall into this category.

A further category would be **vectors**, pests that are no problem to the fruit other than that they vector certain undesirable diseases, such as the citrus psylla which is a vector of citrus greening disease.



# Integrated Pest Management

How do we control these pests? Traditionally, on all agricultural crops, chemical control has been the way in which all these pests have been controlled. But from about the 1950s, certain problems were experienced with chemical control, such as:

- ❖ **Secondary pest outbreaks** from the use of broad spectrum harsh chemicals,
- ❖ The increasing **cost of chemical control** related to rising oil prices, and
- ❖ The **development of resistance** to chemical pesticides

What developed as a result was an approach called integrated pest management (IPM), which is the approach that the Southern African citrus industry adopts towards their pre-harvest pest control for the most part. IPM is a holistic approach to pest management which consists of three main elements.

The first element is that it is a **multifaceted approach** and there are three main factors, being biological control, cultural control and chemical control. The second element would be the use of economic, intervention or action **thresholds**, which would be measurements to determine when one needs to act. The third would be **environmental responsibility** or conservation.



## Pest Monitoring



Within IPM the emphasis is very often laid on the integration of the three types of approaches – biological, chemical and cultural. However, the emphasis should actually lay on management, which implies an understanding.

In order to be a good manager and to practice that good understanding, one needs to be able to accumulate and interpret relevant, accurate and specific data for each and every single orchard and for each and every single pest on that farm. This will determine not only if and when and what is necessary to spray, but almost more importantly, it will determine when it is not necessary to spray, which could be a great cost saving to the farmer and could also be very influential in preserving the beneficial natural enemies in that orchard, which would be jeopardised by a spray.

How does a farmer collect this data? Well, he does so by monitoring, and it is often said that monitoring is the cornerstone of an effective IPM approach.



## Trapping

Monitoring is done through the usage of traps, which could either be traps which attract the pest through **colour**, for example leafhoppers which are attracted to a yellow colour, or through **pheromones**, such as traps for false codling moth and California red scale, or through **food attractants** as is the case with traps for fruit fly females.



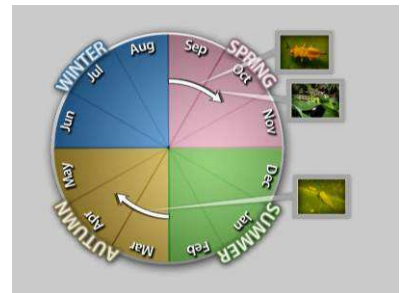
## Scouting

The other form of monitoring is scouting and most pests would be monitored through scouting. This is extremely important. Farmers need to appoint their most trustworthy employees on the farm, make sure that they are properly trained, make sure that they are properly incentivised, and that they have a proper understanding. Scouting needs to be given priority and precedence, and must be conducted regularly on the farm.



The farmer also needs to be aware of when these pests usually occur in the orchards. Certain pests already occur in spring such as citrus thrips and bollworm.

Then there are other pests which only become relevant later in the season. For example, green citrus leafhopper would only appear once the fruit starts to colour up, so monitoring for this pest would only begin much later in the season.



## Pest Control Methods

### Biological Control

Biological control can be **classical** biological control, which is the introduction and release of natural enemies – parasitoids and predators – which do not naturally or did not previously occur in that area.

This however is something that is outside of the hands of the farmer and is something that would be conducted by researchers in the industry.

Then there is **conservation** biological control. This involves recognising the potentially highly effective complex of beneficial natural enemies which are already resident in the citrus orchard.



These parasitoids and predators can very effectively reduce pest numbers, prevent pest outbreaks and even make any further intervention – particularly chemical intervention – unnecessary.

All the grower needs to do is preserve these natural enemies by only spraying when absolutely necessary and then judiciously selecting minimum-impact, short-residual pesticides. In addition, ants, which can disrupt natural enemies, should be kept out of trees.

Finally, there is **augmentation** biological control. In South Africa there are some commercial insectaries, which rear natural enemies for mass release for control of certain key citrus pests.



## Cultural Control

Two good examples of important cultural control are: firstly, to **keep ants out** of the tree. Ants treat sucking insects as if they were their cows. They milk these insects and they protect them against the attack of beneficial natural enemies, parasitoids and predators. Ants are very often responsible for serious outbreaks of sucking insects such as red scale, mealybug and leafhoppers.

The second example of cultural control is **orchard sanitation**. Orchard sanitation is the regular removal of damaged, infested fruit, both from the orchard floor and fruit that are still hanging in the trees, and the destruction of these fruit.

Research has shown in the case of, for example, false codling moth in certain areas, on average over the whole season, 75% of the false codling moth larvae occurring in that orchard can be removed by simple weekly orchard sanitation.



## Chemical Control

The third and last aspect of IPM is chemical control. Chemical control should only be adopted as a last resort and when one does decide to spray, one needs to select very carefully which chemical to use.



# Pest Management Planning

Lastly, planning of one's pest management programme must be done before the season begins.

Planning already begins during the previous season. The farmer conducts a pre-harvest blemish analysis in his orchard before he harvests the fruit. He would do this by conducting a survey of the fruit hanging in his orchard and determining what the major causes of damage are, the major causes of blemishes, and the major cause of infestation of the fruit in the orchard. He would quantify these and these would dictate, in certain cases, which pests would be necessary to control the following season.

Some pests are better controlled by preventative treatment. These would be pests such as California red scale and mealybug.

Some pests are better controlled only by corrective treatment and this means only once the pests has appeared on the tree or on the part of the plant or the fruit where it needs to be controlled. An example of this would be citrus thrips, the reason being that one would want to use a short residual IPM compatible product and there is no point in applying a treatment for citrus thrips before the pest has appeared.



| ORCHARD:<br>CULTIVAR:                 |  | PRE-HAR |      |         |      |         |      |         |      |
|---------------------------------------|--|---------|------|---------|------|---------|------|---------|------|
| DATE OF ANALYSIS:<br>DATE OF HARVEST: |  | 1       |      | 2       |      | 3       |      | 4       |      |
| Fruit no.                             |  |         |      |         |      |         |      |         |      |
| Tree no.                              |  | Blemish | Cull | Blemish | Cull | Blemish | Cull | Blemish | Cull |
| 1                                     |  |         |      |         |      |         |      |         |      |
| 2                                     |  |         |      |         |      |         |      |         |      |
| 3                                     |  |         |      |         |      |         |      |         |      |
| 4                                     |  |         |      |         |      |         |      |         |      |



# Conclusion

Protecting citrus fruit and trees against attacks from pest insects is an essential part of citrus production management. It involves obtaining reliable, current information on the pest status in each orchard, and keeping record of this information.

It also requires that the farm manager keeps up to date with research findings and recommendations. Lastly, it requires that the manager understands how to use all of this information in developing an effective plant protection strategy for his farm.



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# Integrated Pest Management for Citrus

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## 2 Citrus Pest Monitoring

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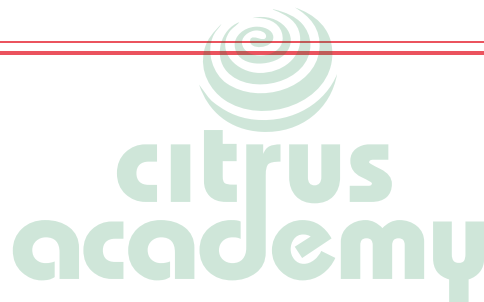


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## information

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## Introduction

Monitoring is the cornerstone of integrated pest management (IPM). It is impossible to implement a successful IPM programme without reliable and efficient monitoring. This consists of either trapping for certain pests, or in most cases and for most pests it will be visual scouting on the tree for the occurrence of the pest itself. In addition to the pest, one can also look for the presence of natural enemies.

All of this helps one in accurate decision-making. Not only does it enable one to determine exactly when to spray and what to spray for, but almost more importantly, it helps one to determine when not to spray. Monitoring can thus result in significant cost saving. Monitoring helps with decision-making in three ways:

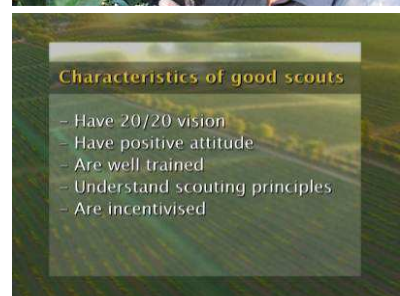
- ❖ It helps with **immediate decision-making** where there is a threshold associated with that particular pest or that pest natural enemy combination.
- ❖ It also helps one to **track pest trends** during the season and make a decision on whether intervention is required depending on how that trend might fluctuate.
- ❖ Thirdly, it enables one to **compare data from one season to the next** and to decide whether intervention is necessary based on historical outcomes.

Therefore, it is very important to record data and to keep records of one's monitoring from season to season so that one can develop a history of pest and natural enemy levels in the orchards and be able to make more and more educated decisions as time goes by.

## Pest Scouts

In order to have an effective monitoring system on the farm, the correct person or people need to be appointed to do the scouting. Farmers need to realise that they need to appoint their most reliable labourer into the position of scout. There are certain requirements for a scout:

- ❖ He must have 20/20 vision
- ❖ He needs to have a good attitude towards his job
- ❖ He needs to be well-trained
- ❖ He needs to understand the principles of scouting. Why is he doing the job? For what purpose is it?
- ❖ Lastly, it would be a good idea for the farmer also to incentivise the scout for good performance



## Scouting Tools

The scout requires certain tools in order to do the job.

Firstly, he needs a good **magnifying glass** or a head loop, then he needs a **pocketknife**, he needs a **scouting form** with a clipboard on which to place it, often tied to a string which he can loop around his neck.

Lastly, he needs a **scouting booklet** which is available from the CRI and has good quality pictures and descriptions of all of the pests and the important natural enemies, where to look for these pests and what sort of symbol to use when filling in observation of this pest into the scouting form. *The scouting booklet is now also available in PDF format, which can be accessed from a smartphone.*

It is very important that scouts complete the scouting form correctly. They need to familiarise themselves with the abbreviations which occur in the CRI identification manual for citrus pests and to use the correct acronyms for each pest that they observe.

On each day that they scout, they need to fill in the date, and the orchard number and the cultivar where they are scouting, and they need to ensure that they scout at least five data trees per each hectare of orchard.

A farmer should appoint more than one scout on the farm to minimise the chance of errors creeping into the work and scouts can double check one another. In addition to this, the farmer should check on the scouts regularly to ensure that what they are recording on the form is indeed what they are finding.



Scouting tools

A screenshot of a scouting form on a smartphone. The form is titled 'CRI' and contains the following information: Name: JOE, Orchard: Sand 3, Pest: Thrips, Date: 7/11, Unit: Fruit. Below this is a table with 10 rows and 10 columns. The rows are labeled 'Tree' and the columns are labeled 'Unit'. The table contains the following data:

|    | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | L | A |
|----|---|---|---|---|---|---|---|---|---|----|---|---|
| 1  |   |   |   | L |   |   |   | A |   |    | 1 | 1 |
| 2  | A |   | A |   |   |   |   | L |   |    | 1 | 2 |
| 3  |   | L | A |   | L |   |   |   |   |    | 2 |   |
| 4  |   |   |   |   |   |   |   |   | A |    | 1 |   |
| 5  |   |   |   |   |   |   | L |   |   |    | 1 |   |
| 6  |   |   |   | A |   |   |   |   |   |    | 1 |   |
| 7  |   |   |   |   | A |   |   | L |   |    | 1 | 1 |
| 8  |   |   |   |   |   |   |   |   |   |    |   |   |
| 9  | A |   |   |   | L |   |   |   |   |    | 1 | 1 |
| 10 |   |   |   |   |   |   |   |   | L |    | 1 |   |

## Data Trees

Data trees should be marked throughout an orchard. There should be a minimum of five data trees used per hectare of citrus and the same data trees should be used week in and week out.

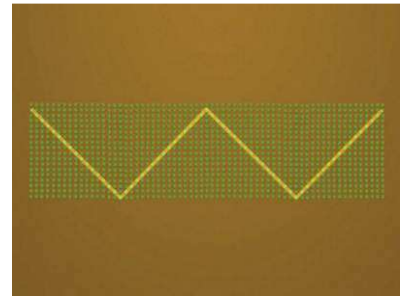
The reason for using the same data trees is that data becomes more reliable. Any variations in pest findings, one can know are not simply because one is using different trees, but are genuine fluctuations in pest levels. This also enables the farmer to return to the exact trees that were monitored by the scouts and check that they did indeed find what they had written on those forms.



Data trees

Data trees should be positioned in a diagonal formation through the orchard or, if it is a large orchard, in a V-formation or in a very large orchard even in a W-formation.

Data trees should be clearly marked with hazard tape or something similar so that scouts can easily return to the same trees that they scouted previously and to ensure that no one else fiddles with these data trees.



## Inspection Points

Depending on which pest one is scouting for, one would look at different part of the tree. These are called inspection points.

For example, if one is scouting for bollworm one would inspect blossom or small fruitlet clusters. If one is scouting for red mite one would inspect leaves. If one is scouting for red scale or thrips or mealybug, one would predominantly scout on the fruit.

There need to be 10 inspection points on each tree. So if one is scouting five trees per hectare, each with 10 inspection points, that is 50 inspection points per hectare.



Inspection points



## Scouting Procedures

### Sweep Surveys

In addition to scouting specific data trees, there should also be periodic sweep surveys conducted. Farmers can assist in these. The reason for this is that pest infestation may not be even throughout the orchard, particularly for certain pests which tend to have a clumped distribution.

This also enables or maximises one's chances of finding these pests elsewhere if they don't occur on the data trees. For example, close to windbreaks, thrips levels are often higher.



Scouting procedures

### Timing

Scouting should be conducted weekly at least until after mid-summer and should be started in spring.

Pests such as thrips need be scouted for at least on a weekly basis and sometimes twice-weekly. As fruit grows and hardens up it becomes less susceptible and scouting can become less frequent.

Other pests such as red scale would normally only appear on fruit in about December, so scouting for red scale is usually not necessary before December, *unless infestation is at a high level*. Pests such as red mite only needs to be scouted for every second week. Other pest such as fruit fly only become a problem once the fruit start to colour up, so monitoring for fruit fly is only necessary in the second half of summer.



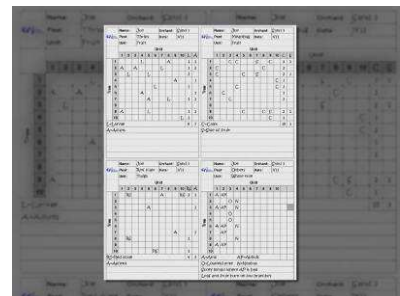
Red scale



Mediterranean fruit fly

## Scouting for Multiple Pests

A scout should not look for too many pests simultaneously. A standard scouting form has four block matrixes, which enables scouting for four different pests simultaneously. This is the maximum that a scout should look for during one scout, otherwise he could lose focus. An inexperienced scout may need to look for fewer pests at a time.



At the end of a day, the scout should immediately report his findings and take his recording forms to the farm manager so that, if any urgent decisions need to be made, the farm manager can do so immediately.

## Citrus Pests

### Thrips

Possibly the most important pest to monitor for is citrus thrips. Because it occurs for the most protracted period during the season, it can cause damage to flush and to fruit from spring or even before fruit set right up until past midsummer.

It can cause damage in a very short period of time and this damage is irreparable. It is a cosmetic pest so it does not damage the internal quality of the fruit but it does cause the fruit to be blemished so that it can be downgraded from export standard.



Citrus thrips

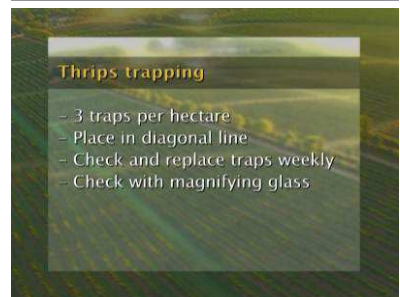
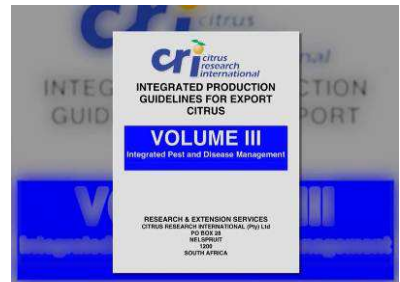
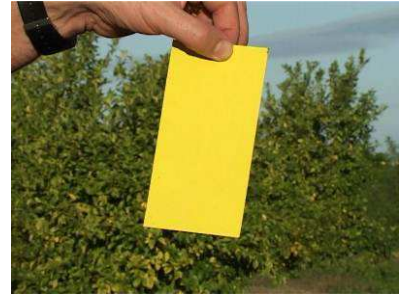
## Trapping

The first way that thrips can be monitored is by use of sticky yellow traps. There are specific dimensions for these traps and one needs to consult the CRI volume III production guidelines for IPM to determine exactly what these measurements are.

The traps then need to be hung out in a density of three traps per hectare in a diagonal line. They are sticky on both sides and they are inspected after a week. One would need a good magnifying glass or even a microscope to see what is on the trap.

This is not a simple way of monitoring for thrips, because there are species other than citrus thrips which can also be attracted to those traps, such as onion thrips and blossom thrips. One therefore needs to be able to differentiate between the different species.

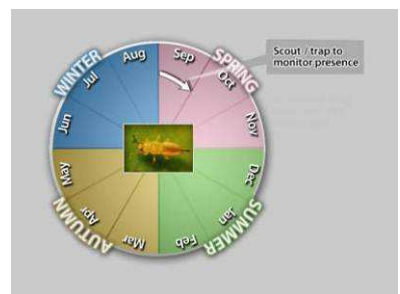
In addition, the catches on these traps can be influenced by climate and by cloud cover. These traps should therefore never be more than supplementary to the more accurate means of scouting, which is visually inspecting fruit and leaves for the occurrence of thrips. *These traps probably have their greatest value when used before blossoms open, in order to give an early warning of thrips pressure and to enable one to decide whether a pre-blossom spray is necessary.*



## Scouting

One would begin by scouting on leaves or using sticky yellow traps in September on the flush which precedes fruit set to determine whether there is any thrips present at all. There is no threshold for finding thrips on flush, but this is something that should be recorded and reported, and is an indication of what thrips pressure could be on the fruit once fruit has set.

When one monitors on the fruit, it is important to do so on a sunny day. Thrips is very inactive if temperatures are cool or if it is a cloudy day, so one does need to wait for a sunny day. Thrips then become more active and moves out from underneath the calyx and is more easily visible on the fruit.



Despite this, one also needs to scout underneath the calyx. This is where the sharp knife comes in handy in order to be able to lift up the points of the calyx and inspect underneath the calyx with a hand lens.

When scouting for thrips on the fruit it is important to be able to differentiate between adult thrips and thrips larvae, the reason being that thrips larvae tends to feed more than adults do and are therefore responsible for more of the damage than the adults are. So scouts need to be trained in the difference between the two life-stages and to record them separately on the recording form.

Immediately after petal drop one needs to start scouting for thrips on the fruit and underneath the calyx.

One needs to be very careful that one doesn't select fruit which have any open blossoms nearby, because those blossoms have nectar in them which can be attractive to other species of thrips, such as blossom and western flower thrips, and one then risks confusing citrus thrips with these other thrips.

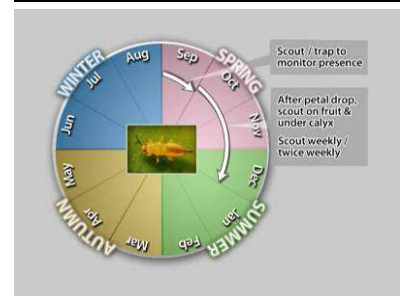
It is easy to avoid this confusion, not only by staying away from fruit which has blossoms near them, but also by specifically recording larvae on the fruit. Blossom thrips larvae are very unlikely to occur on the fruit as they have no business being there.

One needs to scout at least weekly from after petal drop, even twice-weekly would be better, and continue with that right up until December or early January. Thereafter the fruit becomes pretty hardened and into January thrips damage becomes rare.

## Natural Enemies

Citrus thrips has a very effective natural enemy in the predacious mite.

There are a couple of different species of predacious mite which occur in different regions of the country, but they look very similar. They are small, round, pear-shaped, shiny mites that occur on the fruit and occur on the leaves inside the tree.



If one is to scout for them, one would select leaves on the inside of the tree, older leaves that are in a horizontal position. One would pick those leaves and one would inspect for those mites on the underside of the leaf.

Although there isn't a threshold for finding predacious mites which would determine whether one sprays for thrips or not, it is always encouraging to know that this natural enemy is there and is definitely capable of assisting in suppressing thrips, particularly late in the season as a means of preventing late thrips scribbling.



## information

### Thresholds for Predacious Mites

Although we say that there is no threshold, this is only partly true. Although there is no level of presence which will alleviate the need to spray if thrips levels surpass the threshold, if an average of one predacious mite per leaf is recorded, it means that predacious mites will significantly assist in thrips suppression.

### Red Scale

Red scale is also extremely important and was at one time considered to be the key pest in the citrus industry as it can be devastating. Fortunately, current red scale control measures are very effective.

However, if red scale is left unattended it can still be extremely harmful. Not only can it be a cosmetic pest, blemishing the fruit and causing it to be un-exportable, but if red scale infestation is allowed to increase too high, particularly on the woodwork, it can actually cause the tree to go into decline and affect the yield and even cause die-back of the tree itself.

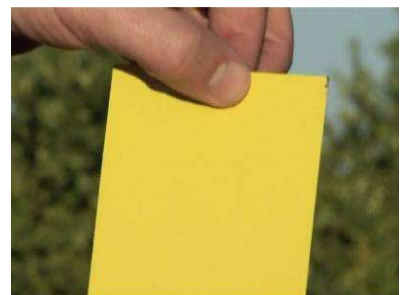


### Trapping

As with thrips, sticky traps can also be used for monitoring red scale. These can either be white or transparent traps or the same yellow traps that are used for thrips.

However, in the case of red scale, one needs to place a pheromone dispenser onto the trap, and that pheromone dispenser needs to be replaced every few weeks.

Traps should be hung at a density of one per hectare and should be inspected weekly.



Elsewhere in the world, such traps are used successfully for determining whether it is necessary to spray or not, in other words, they have a threshold value associated with them.

Unfortunately, in South Africa it has been shown that this is not possible and all that these traps can be used for is determining when to spray, particularly if one is using an insect growth-regulator where the spray works most effectively against the younger life-stages of the insect and *accurate* timing of the application of the spray is very important.

Also, it is important if one is releasing parasitoids for red scale, such as the *Aphytis* parasitoids, that timing of these releases are well synchronised with the young life-stages.

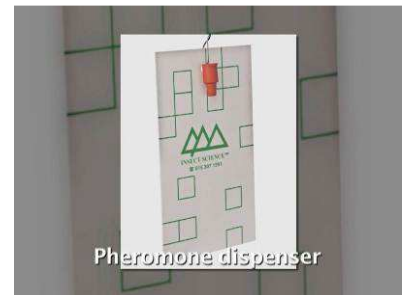
Although California red scale is known as a sessile insect which sits motionless on fruit, stems, and leaves, in fact the adult male life-stage is flighted and it is this life-stage which is attracted to the traps. By monitoring and counting these males that are caught on the trap on a weekly basis, one can determine timing of spray applications.

## Scouting

Although traps can be used for red scale, it is far more important and far more accurate to scout on the fruit, so the fruit is the inspection point for red scale. One would select, as with thrips, 10 fruit at random per data tree and one would record whether there is any red scale present on that fruit and on the stems leading up to that fruit.

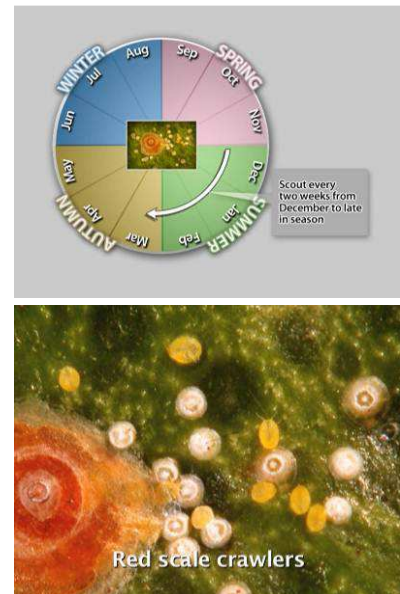
Red scale tends to move very slowly and so normally red scale will only appear on the fruit for the first time in December. Therefore inspections for red scale on fruit should only start in early December and should continue until fairly late in the season, until the grower is satisfied that there is a sufficient decline in red scale in order for it no longer to be a threat to the crop.

Because red scale numbers build up very slowly, and because red scale moves slowly, it is not necessary to scout weekly as in the case of thrips. Scouting every two weeks is more than adequate with red scale.



When scouting for red scale the scout should take 10 fruit at random without looking first to see whether there is anything on the fruit, and he should turn the fruit around *while inspecting*.

He may need a magnifying glass to inspect for *all* life-stages of red scale. The smallest life-stage of red scale is the very small yellow crawlers, whereas the larger life-stages are very easy to see. Not only would he look around the entire fruit, but he would look on a portion of the green stem leading up to that fruit.



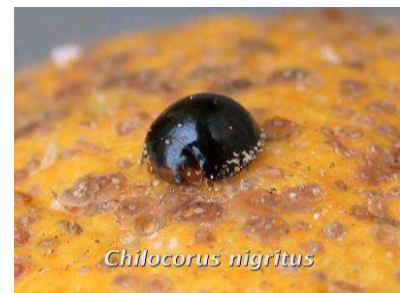
## Natural Enemies

Natural enemies are also very important for red scale control. There are a few species of parasitoids or wasps which are important to parasitize red scale. They are very small, mostly microscopic and not that easy to see.

However, to the trained eye one can begin to recognise what a parasitized red scale looks like. In addition, one can collect red scale infested fruit from non-data trees, take them back to the office and inspect under the microscope whether these red scale are parasitized or not.

This can assist greatly in the decision-making on whether it is necessary to spray or not.

In addition to the parasitoids, in certain regions of the country, particularly the northern regions, certain ladybird predators are very important, such as *Chilocorus nigritus*, which is a round, black lady beetle about 5mm in diameter.



## Mealybug

Mealybug is primarily a cosmetic pest. Mealybug can cause raised shoulders of the fruit by feeding on young fruitlets underneath the calyx. Mealybug can also cause honeydew which leads to the growth of sooty mould, which causes unsightly blemishes on fruit. It can also cause little pink scarring blotches on the fruit.



Mealybug can also be a precursor to certain secondary pests and diseases, such as carob moth and *Alternaria* navel-end rot, which is associated with mealybug infestation.

However, mealybug can also be a phytosanitary pest. There are seven species of mealybug which occur on citrus in South Africa and some of those species don't occur in some of our export countries and we therefore need to make sure that they are not on the fruit at the time of export.

Fortunately, most of these are the less common species of mealybug and the most common species is citrus mealybug which is a cosmopolitan pest.



## Scouting

As with red scale, the primary decision or the first decision on whether it is necessary to spray mealybug or not, is made on the basis of the pre-harvest blemish analysis from the previous season.

However, this must not prevent one from starting with inspections in winter, leading into spring. One starts by inspecting the woodwork, the trunks and the branches, in winter and if there is any obvious infestation of mealybug, then one would intervene.

As spring approaches, one inspects leaves, blossoms and small forming fruitlets. Any obvious infestation at this early stage of the season should be recorded and action should be taken.

The inspection point for mealybug is the fruit, and, just as with red scale and thrips, one would look around the tree and randomly select fruit and inspect underneath the calyx.

Primarily one would need a sharp knife to lift up the calyx. Try not to break the fruit off because that would eventually diminish the number of fruit available for inspection on the data trees.

Carefully lift the calyx with the knife and inspect underneath the calyx with a magnifying glass to determine whether there is any mealybug infesting underneath the calyx. This could be anything from large adult life-stages to very small brown crawlers which would need a magnifying glass to see.



A well-trained scout should also be able to differentiate between the different species of mealybug that can occur on citrus. It is important that, if he finds the adults of mealybug, he is able to write down on his form what species he observed.

For the first six weeks after petal drop, inspections should be conducted weekly. This is the high risk period and because the calyx is only just closing onto the fruit during this time, if a spray is applied during this first few weeks after petal drop one can more easily get good penetration of spray underneath the calyx.

After the first six weeks post petal drop one can reduce scouting to once every two weeks.

Apart from under the calyx, mealybug can also occur on the cheeks of the fruit and inside the navel-end of navel oranges, so one must also inspect there.

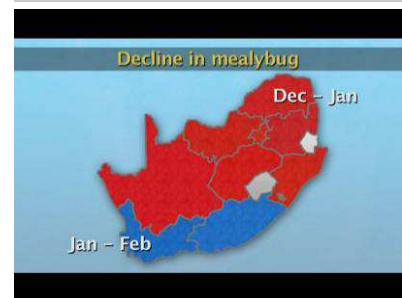
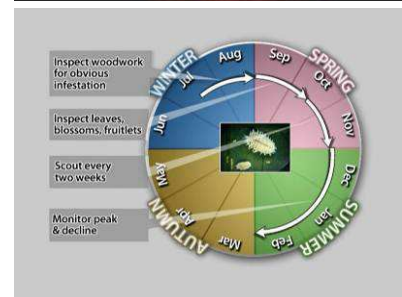
Scouting for mealybug should continue at least until February. This is very important because decision-making is now based on tracking the trend. Mealybug levels ought to build up to a peak in December or January, at which time natural enemies get on top of mealybug, and one should see a significant decline in the northern areas from December to January and in the Cape areas from January to February.

One is only able to determine whether this decline occurs if one is scouting regularly. If this decline does not occur, the farmer is in a position to immediately make a decision whether intervention is necessary or not.

## Natural Enemies

Mealybug has a very effective biological control complex, almost more effective than most species that occur on citrus. However, it is not that easy to observe this complex. If mealybug is parasitized, the parasitized life-stages will often drop off the fruit and won't be easy to detect.

However, there are certain parasitoids which will be easy to see such as *Anagyrus*, which has distinct white antennae, and then a couple of the beetle predators of mealybug such as *Nephus* and *Cryptolaemus* beetles.

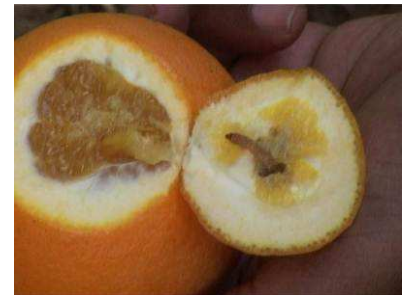


Although it is not possible to attach a threshold to the occurrence of these natural enemies, finding them in the orchard is a good sign and can fill the scout and the farmer with confidence that biological control is playing a significant role in the suppression of mealybug levels.



## False Codling Moth

False codling moth is also a major pest. The female moth lays her eggs on the fruit, the larva hatches out of the egg and penetrates into the fruit and causes the fruit to decay and drop off the tree. This can cause significant crop loss. If infestation occurs shortly before the fruit is picked at harvest time, the fruit can then decay on the way to the market.



Most importantly, false codling moth is a pest that only occurs in sub-Saharan Africa and therefore our markets do not want that pest. This is a major reason why we need to rid our orchards as far as possible and certainly our fruit of false codling moth infestation.

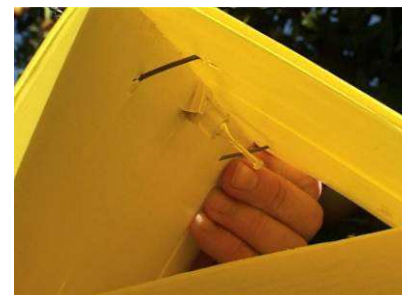
## Trapping

Firstly, false codling moth is monitored through the use of pheromone traps. These traps are loaded with the pheromone of the female moth which attracts male moths to the trap.

Preferably delta traps should be used, however, PVC pipe traps are also an option. Both of them have a sticky lining at the bottom and these traps are inspected weekly to find out what has been caught in the trap.

Traps should be hung out at latest in early November and should be monitored all the way through until harvest.

One trap should be used per four hectares. The positioning of the trap is extremely important. The trap should be hung in approximately the fifth row of the orchard and approximately five trees in the orchard. The trap must be hung on the southern or shady side of the tree and it must be hung high up in the tree, at least at head height.



The trap must be hung on the upwind upside of the orchard so that the wind can blow the pheromone into the orchard. Male moths fly against the wind so they can detect the pheromone of female moths.

It is very important that the traps should be free-swinging and that there is no hindrance to the trap. Therefore, the scout when hanging the trap should use a pair of pruning shears to cut away any branches or leaves or twigs which could obscure the accessibility of the trap to the moth.

Each week on the same day the scout should approach the trap and remove the sticky floor counting the number of moths that have been caught in the trap *and removing the moths so that they are not recounted the following week.*

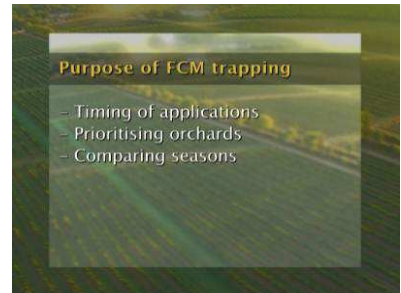
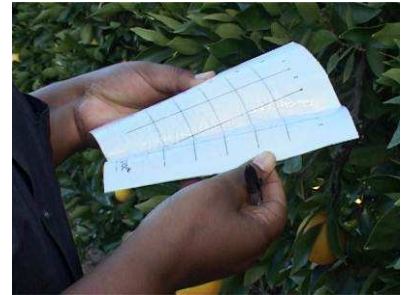
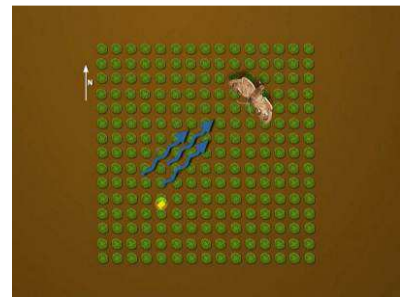
If he is unclear as to what is a false codling moth, because other moths and insects are sometimes also inadvertently caught in the trap, he should consult the CRI scouting manual in order to get an accurate identification of the moth.

If the sticky floor is dirty or has been used for a few weeks and a lot of moth residue remains on the sticky floor, the scout can replace the sticky floor with a clean one.

The scout should also bear in mind how long the pheromone dispenser lasts. There are *at least two* pheromone dispensers that are currently commercially available on the market. Each one lasts for a different duration of time, so the scout or the farm manager must be familiar with that.

As the season progresses, fruit grows and becomes heavier and begins to weigh branches down. The position of the trap is therefore likely to drop lower and lower. The scout needs to be aware of this and reposition the trap higher into the tree and to again prune away branches that might be hindering access to the trap.

Previously, traps use to be used for threshold purposes, in other words determining whether it is necessary to spray for false codling moth or not. False codling moth has now become such an important pest that all growers need to take some sort of action to control false codling moth, so those thresholds have fallen away.



So what then is the purpose of the trap?

- ❖ The traps are used for accurate **timing of application**, particularly if a virus spray is being applied
- ❖ The traps are also used for **prioritising one orchard** against another – whichever orchard is showing the highest catches the grower will know he has to intervene there first
- ❖ In addition, growers are able to **compare one season** with another

## Fruit Infestation Inspection

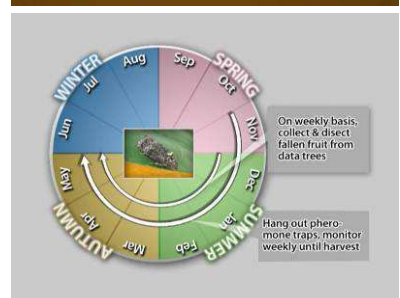
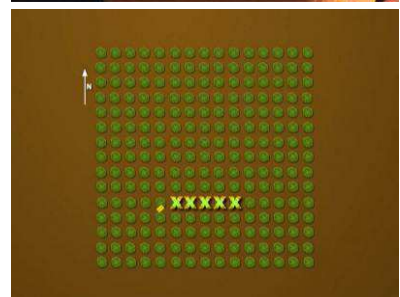
Another form of monitoring is inspection of fruit infestation. This is in fact even more important than monitoring traps for false codling moth. The reason is that what one really wants to know is: what is the risk of my fruit being infested or if it is infested at all?

In order to do this, one needs to mark out a certain number of data trees. One can use the same data trees that one is using for scouting; however, it might be easier to mark out five fresh data trees which are adjacent to the trap tree.

The data trees should be clearly marked and it needs to be ensured that no one other than the scout ever picks up fruit from those data trees. On a weekly basis, on the same day the scout needs to collect all the fruit that had fallen underneath the data trees. Then he needs to dissect those fruit and determine what the cause of the drop is.

It is fairly easy to determine whether fruit has dropped as a result of false codling moth. Either a false codling moth larva needs to be found in the fruit, or signs that a false codling moth larva was in the fruit, in other words the frass granules of the larva, must be found in the fruit.

The scout must be made aware that there are other insects that can infest the fruit, such as fruit fly, so he needs to be clear about the identification of the larvae. False codling moth larvae can be very small, predominantly white in colour, to relatively large, about 1.5mm in length, and dark pink in colour.

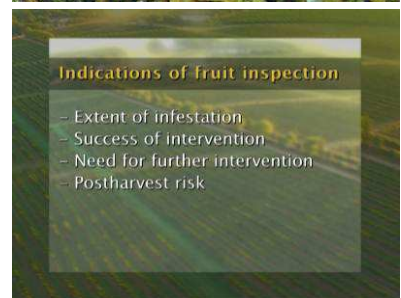


Although inspection of fruit infestation is an indication of damage that has already happened, the information that goes to the farmer is extremely valuable.

- ❖ It shows him the **extent** of the problem in the orchard,
- ❖ It shows him how well his **intervention programmes** are working
- ❖ It shows whether **further action** is required, and
- ❖ It shows him what his **postharvest risk** is likely to be



False codling moth larva



## information

### Fruit Infestation Inspection

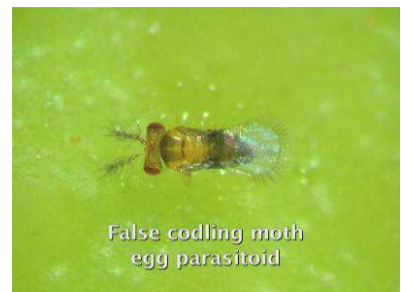
In addition to the points listed above, fruit infestation data also gives an indication of **other causes of fruit loss**, which is an important indication when deciding on control measures for other pests and diseases.

### Natural Enemies

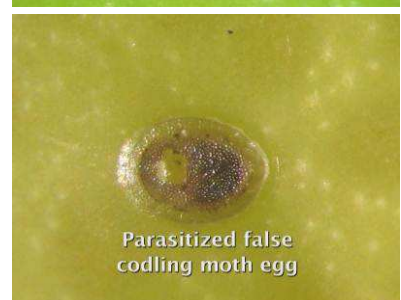
The most effective natural enemy of false codling moth is a very small egg parasitoid. Scouts can monitor for this too.

They would do so by using fruit as the inspection point and would randomly select 10 fruit per tree. On these fruit they can record false codling moth eggs, and the number or percentage of these eggs that are parasitized. A parasitized egg is very easy to differentiate from a healthy egg – a parasitized egg turns pitch black.

This parasitoid is extremely effective and can parasitize in excess of 80% of the eggs. Such a finding would be great encouragement to the farmer that his FCM levels would remain well suppressed until harvest.



False codling moth egg parasitoid



Parasitized false codling moth egg

### Fruit Fly

There are two species of fruit fly which are important on citrus. This is the Mediterranean fruit fly (*Med fly*) and the Natal fruit fly (*Natal fly*).

The female damages the fruit by attempting to oviposit or successfully ovipositing her eggs through the rind of the fruit. Even if there isn't a successful oviposition, the penetration hole which she makes is large enough to allow secondary infection to occur and to cause that fruit to decay and drop off the tree.

If the eggs are successfully laid underneath the surface of the rind, the larvae will hatch out and the maggots will develop into the fruit also causing the fruit to decay and drop off the tree.

## Trapping

The only way in which fruit fly can be monitored is through the use of traps. There are two traps which are registered and commercially available for monitoring fruit fly in citrus. However, only one of these has a threshold value associated with it and this is the Sensus trap. The Sensus trap can be loaded with either Capilure or Questlure. There are other lures available but the use of either Questlure or Capilure, or preferably both of them, is even better. They should not be used together in the same trap and traps loaded with Questlure and Capilure should be separated by at least 50m of distance.

Traps should be hung at a density of between one per two hectares and one per six hectares, depending on the size of the farm. Capilure is red in colour, and is used mainly for catching male flies. Questlure is green in colour and is used mainly for catching female flies.

Traps should be monitored every week on the same day. The scout should remove the flies from the traps and should identify the flies to species, and should differentiate between male and female flies. Thresholds for Medfly and Natal fly and for males and females differ.

The lures and the dichlorvos tablet should be replaced every six weeks. The dichlorvos tablet kills any flies that fly into the trap.

Fruit only becomes susceptible to fruit fly once it begins to colour up. Fruit starts to colour up about two months before harvest, so these traps should be hung out about three months before harvesting begins. However, where fruit fly pressure is known to be very high, traps should be hung much earlier in the season.



## Natural Enemies

There are no natural enemies of fruit fly that one needs to inspect for.

## Oriental Fruit Fly

*The Oriental fruit fly, also known as Bactrocera dorsalis (and previously known as Bactrocera invadens), is of Asian origin. It was first discovered in Africa, in Kenya, in 2004. Since then, it has dispersed north and south of the equator.*

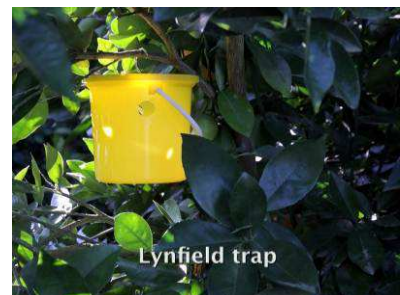
*It was recently declared present in South Africa, with very limited distribution in certain northern parts of the country. Every effort should be made to prevent it from establishing elsewhere in the country. Therefore, it is important to monitor for the pest.*



## Trapping

*To monitor for Oriental fruit fly, a bucket trap (there are four types) is loaded with a methyl eugenol dispenser (various are commercially available), and a dichlorvos tablet to kill any flies entering the trap.*

This monitoring system is highly effective at attracting and catching adult male Oriental fruit fly. *Between one and five traps must be hung per hectare, depending on whether Oriental fruit fly is present, under eradication or absent.*



Traps must be hung on the shady side of the tree, within the tree canopy and as high as possible above the ground.

Traps are monitored weekly and catches must be recorded even if these are zero, which is important to demonstrate that the farm is free of Oriental fruit fly.

Lures and toxicant tablets must be replaced every six to eight weeks, depending on which lure dispensers are used.

## Bollworm

Bollworm is only a pest in spring. The female moth is attracted to lay her eggs on the blossom, even before the blossom opens. The larva hatches out and begins to

feed on the blossom clusters. Once the fruit sets, the larvae move over to the fruit and start feeding on the small fruitlets.

Bollworm causes damage and losses in three different ways. Crop load can be reduced by heavy feeding on blossoms and fruitlets. Even if fruitlets don't drop off the tree and *develop to maturity*, they could carry an ugly scar and make them unfit for export. Finally, where there is an overlap of spring blossom with late hanging ripe Valencia fruit, the larvae can feed on these fruit.



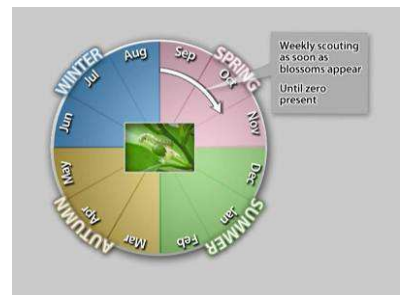
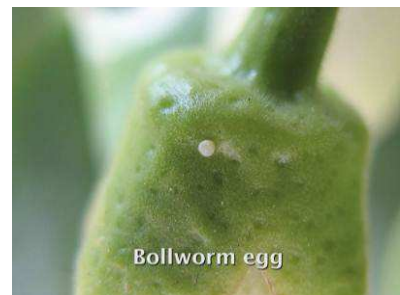
## Scouting

Scouting for bollworm will start in spring, as soon as there is blossom on the tree.

The scouting units are blossom clusters, which eventually become fruitlet clusters. The scout will select at random 10 fruitlet or blossom clusters per tree and inspect these for any life-stage of bollworm. Eggs are small and round and are ridged from top to bottom. Larvae are initially small but grow into very large caterpillars measuring a few centimetres in length.

The scout doesn't need to record number of individuals per blossom or fruitlet cluster, simply whether it is infested or not. Life-stage recorded is also generally not important, unless the grower is planning to apply a soft option, such as *a baculovirus product or Bacillus thuringiensis*, which are only effective against small larvae.

Scouting must be conducted once a week and it must be continued either until there is no bollworm present any more, or until the grower has sprayed successfully for the pest.



## Budmite

Budmite is a microscopic pest which infests the axial buds of developing new growth on a citrus tree. Ultimately what happens is that the fruit is damaged at the end of the day and the symptoms of this damage are ridging, protruding navels, particularly on navel oranges, and the flattening out of the fruit.

Because budmite is microscopic, it is very difficult if not impossible to find this pest on a citrus tree, so the only real way to look for this pest is to look for signs of damage.



## Scouting

In spring one will inspect developing blossom on the tree and look for signs of blossom malformation on the tree.

The scout will select at random 10 blossom clusters on each data tree and will inspect these for any signs of malformed blossom. This is the most important time for inspection for bud mite.

However, the scout can also inspect each new flush which occurs throughout the season to look for shortened internodes, or any other signs of malformation on the leaves.



## Red Mite

There are a number of other mite species that can be a pest on citrus. Most of these are fairly sporadic and many of them are fairly minor.

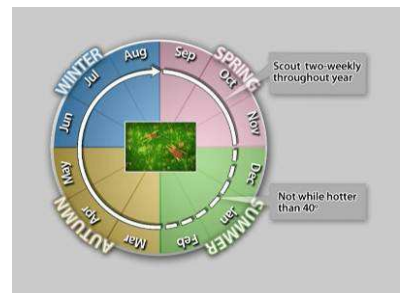
However quite important is the red mite. Red mite is a pest on both leaves and on fruitlets. It causes a greying of the leaves and can even cause a silvering of the fruit if infestation is severe. If infestation of the leaves is particularly severe, leaves can even drop off the tree.



## Scouting

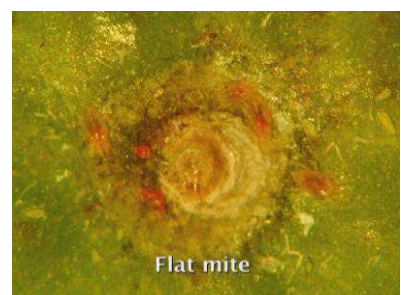
Inspection point for red mite is both fruit and leaves. The scout will take fruit at random, 10 per data tree, and count the number of mites on the fruit. He will also take leaves, 10 at random from the tree, and count the number of mites on the upper side of the leaves.

Red mite can be a pest throughout most of the year so scouting for red mite should be conducted at two weekly intervals throughout the year, except in the hottest months. Temperatures above forty degrees tend to be fatal for red mite.



## Flat Mite

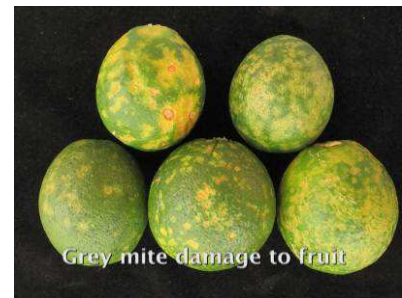
Another fairly important mite pest is the flat mite. Flat mite often feeds on the edges of other scars such as thrips scars and wind scars and even feeds underneath red scale, causing an exacerbation of the scarring. Flat mite should be inspected for on the fruit and can occur at any time during the summer.



## Other Mites

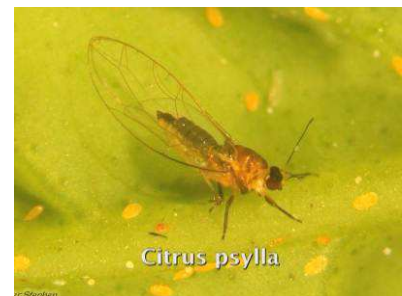
There are a number of other species of mite which can be pests on citrus, both on the fruit and sometimes on the leaves too and these are species like:

- ❖ Grey mite
- ❖ Oriental or Lowveld mite
- ❖ Rust mite
- ❖ Red spider mite
- ❖ Silver mite



## Citrus Psylla

Citrus psylla is the vector of greening disease, so particularly in areas where greening disease occurs, scouts must be vigilant in looking for citrus psylla. In other areas, psylla is nothing more than a cosmetic pest.



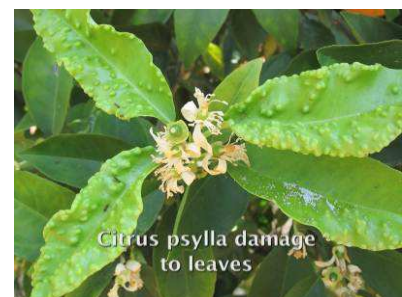
## Scouting

Citrus psylla infestation is recognisable by the pockmarking that infestation from young stages results in on leaves.

However, in areas where greening occurs, scouts want to detect the presence of citrus psylla before these extreme symptoms on leaves show up.

The first signs of infestation would be the laying of eggs on the perimeter of leaves and the settling of juvenile stages on the leaves, so the inspection point for citrus psylla is leaf clusters. The scout should select 10 leaf clusters at random around the tree.

Citrus psylla will only infest new flush, so whenever there is a new flush on the tree, an inspection must be made for citrus psylla. While the flush is still soft, weekly inspections of this flush must be made. Once it has hardened up, it is no longer attractive to citrus psylla, and scouting for this pest can be put on hold until the next flush shoots.



## Other Scales

### Mussel Scale

Mussel scale is not normally a pest in citrus orchards, particularly where a conventional spray programme is being followed. Therefore, routine monitoring for mussel scale is not necessary.

However, if mussel scale is observed, then fruit must be monitored for mussel scale in a very similar way that would be used for red scale inspection.



### Waxy Scale

Waxy scale is also a fairly sporadic pest. Infestation by waxy scale can be on the green stems or on the leaves.

Waxy scale doesn't settle permanently on the leaves, but in its growing life-stages would settle temporarily on the leaves and then move back to the stalks.

Routine scouting for waxy scale is not necessary, but if the scale is observed, then the scout should inspect for waxy scale by using leaf clusters as the inspection points. Stems should be included in these inspection points.



### Soft Scales

Soft scales, like waxy scales, *soft green scale* and *soft brown scale*, are sporadic pests. Normally one does not need to scout for soft scales but if their presence becomes obvious, then scouts should inspect for them too. The main problem with soft scales, like waxy scale, is the production of honeydew which leads to the growth of sooty mould, which can land up on the fruit and cause the fruit to be downgraded for export.

The inspection point for soft scales, is the leaves and the green stems leading up to the leaves.



## Australian Bug

Australian bug (*cottony cushion scale*) is also a sporadic pest. In fact, Australian bug should never be a pest. Australian bug has arguably the most effective predator of all citrus pests. This is the *Vedalia* beetle, which normally keeps Australian bug at levels which are not even detectable.

If Australian bug is present, it will be seen mainly on the tree trunk and on the scaffolding branches. There is no real scouting system for Australian bug, but the presence of the pest must be recorded.

Simultaneously it is very important to look out for *Vedalia* beetles. If they are present, then this will probably eliminate the need to spray for the pest. Additionally, one needs to look out for ants, as ants can disrupt the natural enemies of Australian bug. If ants are present, these need to be controlled immediately.



## information

### *Rodolia cardinalis*

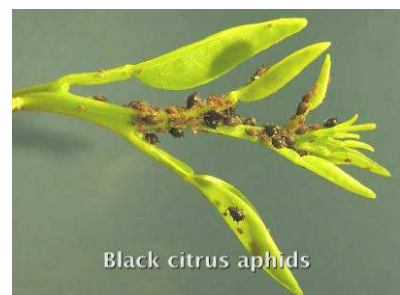
The scientific name for the natural enemy of Australian bug is *Rodolia cardinalis*. It is commonly known as the **Vedalia** beetle or cardinal ladybird.

## Aphids

Aphids are generally not a serious pest, particularly on bearing trees. Trees can tolerate a low level of aphid infestation. On non-bearing trees aphids become important and the trees can tolerate less. The presence of aphids must be recorded.

There is no specific monitoring system for aphids, however. If it is noted that there is a general increase in the infestation level of aphids, and if there is an unacceptable level of honeydew and sooty mould developing, then this must be immediately reported by the scout to the farmer.

Aphids are vectors of tristeza disease, particularly the black citrus aphid, and grapefruit is particularly susceptible to citrus tristeza disease. Therefore, if an aphid infestation is detected on grapefruit trees this must be immediately reported to the farmer so action can be taken.



## Leafhoppers

Leafhoppers are sporadic pests. In fact, in most areas leafhoppers never reach pest status level.

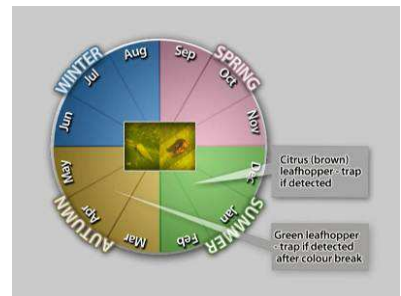
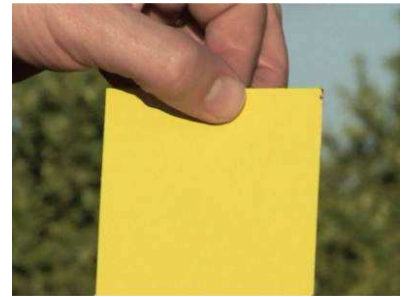
There are two species of leafhoppers which are of primary importance on citrus. This is the green citrus leafhopper and the citrus leafhopper, which is brown and larger than the green citrus leafhopper.

Monitoring for these pests is done mainly with the sticky yellow traps, similar to those used for citrus thrips. These traps should be checked and replaced on a weekly basis. As for citrus thrips, a density of three sticky yellow traps per hectare should be used.

The sort of damage that can be caused by leafhoppers is an oleocellosis type of blotching on the fruit, which can then be downgraded at time of harvest.

The brown citrus leafhopper generally becomes a pest earlier in the season than the green citrus leafhopper. The brown citrus leafhopper can be a pest in midsummer. If the pest is detected, then the sticky traps should be placed out in an orchard.

Only once fruit starts to colour up, is the green citrus leafhopper usually a problem. If this is noted, then traps should be placed in the orchard.



## Citrus Butterfly

There are two main species of butterfly which are pests on citrus. They are large butterflies, which are generally yellow and black in colour. The female lays her eggs on young flush. The larva hatches out and the caterpillar feeds on this flush.

It is very rare that it is necessary to take any action on citrus butterflies on bearing trees. However, no infestation of citrus butterflies or their larvae can be tolerated on non-bearing trees. In a short period of time, the flush can be damaged by these.

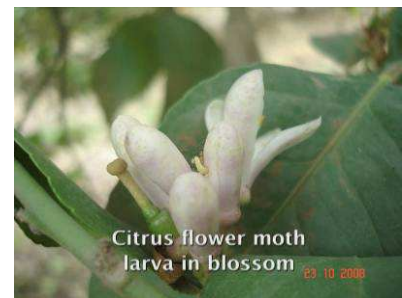
Therefore, if a scout sees any larvae or eggs of citrus butterflies on non-bearing trees, these must be recorded and reported immediately.



## Citrus Flower Moth

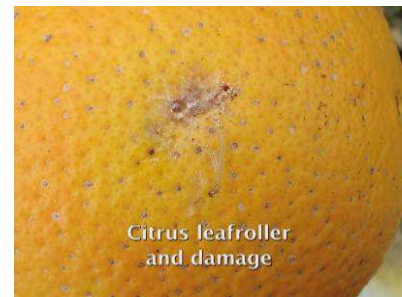
Citrus flower moth is generally only a pest on lemons. The female will lay her eggs on or near the blossoms, the larvae will hatch out, and they will begin to penetrate into and feed on the blossoms. If this generation is large and left to reproduce, the second generation can attack the fruitlets, the moth laying her eggs on the fruitlets and the larvae penetrating into the fruit and damaging the fruitlets.

Lemons should be inspected for citrus flower moth whenever there is a new blossom on the tree. This happens usually *three or* four times a year with lemons. Therefore, the blossom clusters form the inspection points. Scouts must determine what percentage of these inspection points are infested with citrus flower moth larvae or pupae.



## Leafroller

There are two species of leafroller which occur on citrus, the most important being the apple leafroller. The larvae of the leafroller tend to roll leaves together using their webbing, hence their name. However, the damage that they cause is by feeding underneath the calyx of the fruit. As the leafroller occurs during the period that thrips occurs, as one is inspecting for thrips, one can simultaneously monitor for leafroller larvae.



## Ants

There are a number of different species of ants that occur in citrus orchards. However, there are two species that are overwhelmingly more important than any other species. These are the brown house ant, which is by far the most important, and the pugnacious ant.

Scouts need to inspect both in the trees and on the ground for the presence of ants and they need to record the percentage of trees where they find ants to be present. Although ants are not direct pest to citrus, they are extremely important as they disrupt the natural enemies of many other pests. Sucking insects produce honeydew and honeydew is attractive to these ants.

As these ants want to feed on this honeydew, they protect these sucking pests against the attack by their natural enemies. As a result, biological control of these sucking insects is seriously compromised by the presence of ants.



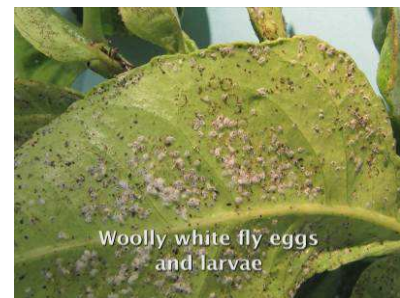
## Woolly Whitefly

Contrary to what the name suggests, *woolly whitefly is not a fly*, but is more closely related to scale insects and aphids.

The adults look like tiny moths and fly around rapidly, while the larval stage sucks onto the undersides of leaves.

The larvae produce honeydew, which leads to the growth of sooty mould, which can cause fruit to be unfit for export and can impede photosynthesis. Honeydew also attracts ants, which in turn protect the woolly whitefly from its natural enemies.

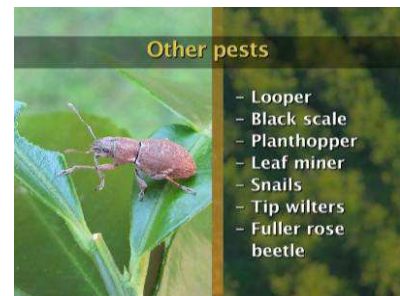
Scouts must be on the lookout for the presence of both adult and larval woolly whitefly, and report it to the farmer without delay.



## Other Citrus Pests

A well-trained and observant scout should be able to detect pests which don't normally occur in the orchard. These could be pests such as:

- ❖ Looper
- ❖ Black scale
- ❖ Planthopper
- ❖ Leafminers
- ❖ Snails
- ❖ Tip wilters
- ❖ Fuller's rose beetle



## Conclusion

In conclusion, the importance of scouting and the importance of the scout who conducts the work can never be over stated. This is arguably the most important function that can be performed on a day-to-day basis on a farm.

This practice will not only save the farmer money, but it can save him innumerable losses. It is an extremely important function and one which should never be neglected on the farm.

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# Integrated Pest Management for Citrus

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## 3 Pre-Harvest Blemish Analysis

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Learner Guide

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Media World

**Additional information sources:**  
Citrus Production Guidelines: Volume III – Integrated Pest Management, *Citrus Research International*

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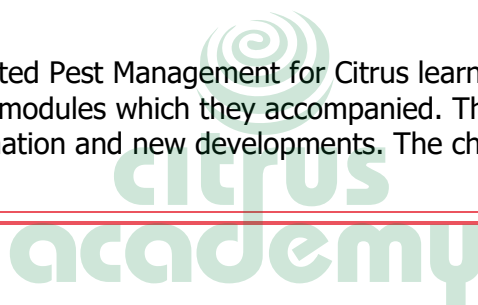
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## information

### *Second Edition*

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## Introduction

A blemish factor analysis is a very important exercise which needs to be conducted at the end of every season. This helps greatly in decision making for a pest management programme for the following season.

## Purpose of Analysis

A blemish factor analysis effectively does four things:

- ❖ It comments on the **pest and natural enemy trends** observed through scouting during the course of the season.
- ❖ It also comments on the **threshold** which had been applied by the farmer during the course of that season. *Although many thresholds have been scientifically determined, many others are still in the process of development and it can also not just be assumed that thresholds will be identical in each different area.*
- ❖ Thirdly, the blemish factor analysis comments on the **success of the spray programme** applied during the season, and
- ❖ It helps in establishing what sort of spray programme to follow for the **following season**.



## Fruit Collection Procedures

A blemish factor analysis can be conducted either in the orchard or at the packhouse.

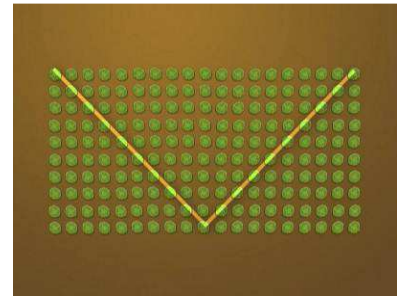
However there are problems associated with conducting this analysis at the packhouse. If fruit are delivered to the packhouse and a sample is taken from the picking bin at the packhouse, this sample is unlikely to be representative of the orchard as a whole. It is likely to represent only a small section of that orchard.

The second problem is that fruit are often preselected in the orchard. In other words, the worst blemished fruit, which is unlikely to make the export standard, will be thrown out in the orchard and won't even make it to the packhouse.

It is therefore better to conduct such an analysis in the orchard. Growers or scouts should select 50 to 100 fruit per hectare at random and conduct the analysis on these fruit. Fruit can be analysed while they are still hanging in the tree or the fruit can be picked and analysed at a later stage.



It is important that these fruit which are selected are not just from one section of the orchard but that they are representative of the entire orchard. Therefore, trees at random and fruit at random should be selected throughout the orchard in a similar sort of formation as what would be used for scouting, i.e. a diagonal line, or a V- or W-shape.

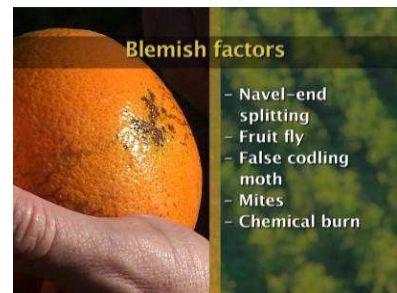
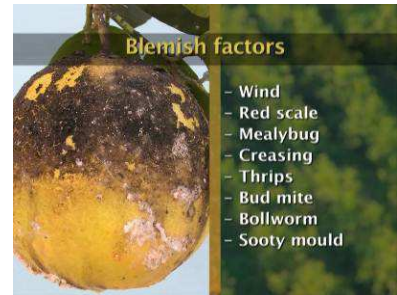


## Fruit Blemishes

Every single blemish factor on the fruit should be noted and recorded. It should also be noted whether the blemish factor is just a minor scarring or whether it is sufficient to downgrade the fruit for export. In order to determine that, one needs to get hold of Citrus Research International's (CRI) blemish standards booklet so that one can categorise what is acceptable and what is not acceptable for export.

Blemish factors which should be recorded are factors such as:

- ❖ Wind
- ❖ Red scale
- ❖ Mealybug
- ❖ Creasing
- ❖ Thrips damage, and one can categorise this thrips damage as early damage, late damage or thrips scribbling
- ❖ Bud-mite damage
- ❖ Bollworm damage
- ❖ Sooty mould
- ❖ Navel-end splitting
- ❖ Fruit fly
- ❖ False codling moth
- ❖ A range of mites, e.g. flat mite, rust mite, silver mite
- ❖ Other factors, such as chemical burn



### Blemish Example: Thrips

Here I have selected a few examples of thrips damage. This first one, for example, shows very severe thrips damage from early in the season when the fruit was still small. Remember that all of the feeding early in the season occurs underneath the calyx, so the further the damage has grown from the calyx, the earlier the



damage was inflicted.

The fact that there was no break in the damage from right up to the stem-end to far from the stem-end means that there was inadequate or no thrips control during the course of almost the entire early season.

The second example shows just a ring of thrips damage where between that ring and the stem-end it is clean. So at a fairly early stage during the season, thrips control was inadequate. Possibly scouting didn't pick up the presence of thrips early enough or the product which was used was not effective enough or reapplication of the product wasn't rapid enough. However, thereafter it appears that thrips control was adequate. Both of these examples are probably likely to downgrade the fruit for export.

*The third examples* shows an even less severe case of thrips damage, just a single ring of damage which occurred for a very short period of time. This may or may not downgrade the fruit for export. This example shows a very small sector of thrips damage and it is unlikely that this will downgrade the fruit for export.

Another example is late-season thrips damage which doesn't occur underneath the calyx, but occurs on the side of the fruit. This is called thrips scribbling.

Finally, a fairly unusual form of thrips damage is damage around the navel-end, also clearly sufficient to cause downgrading of the fruit. This would also have occurred probably later on during the season.



### ***Blemish Example: Budmite***

There are three different symptoms of bud mite damage on fruit, i.e.:

- ❖ Ridging around the calyx-end
- ❖ A general flattening of the fruit, and
- ❖ Protrusion of the navel-end in navel oranges



## Blemish Analysis Records

The information that is gathered when the fruit sample is inspected is entered on a form similar to this one.

In this example, each block on the grid represents a fruit. For instance, this block is for the first fruit from data tree number three.

Blemish codes are used to indicate the type of damage to the fruit. The code is entered in either the blemish column or the cull column, which is an indication of the severity of the damage. For instance, if the first fruit from data tree three has thrips damage that will downgrade it from export quality, hence T is entered in the blemish block for this fruit.

If the second fruit from the same tree for instance is infested with a fruit fly larva, FF is entered into the cull column under this fruit, because this type of damage means that the fruit has to be culled and cannot be sold at all.

If a fruit has more than one type of blemish, the codes for all the different blemishes must be entered. For example, if the third fruit from data tree three has wind scarring, bollworm damage and navel-end-splitting, W and BW is entered into the blemish block for the fruit and NES in the cull block.

If there is no damage to a fruit, a dash or line through the block is used as an indication.

Once all the blocks have been completed, the numbers of blemishes and cull factors are added up and entered into the blocks at the bottom of the form. This information can be entered into a summary sheet along with information from other orchards, where it can be analysed further.

**PRE-HARVEST FRUIT ANALYSIS FORM**

ORCHARD: \_\_\_\_\_  
CULTIVAR: \_\_\_\_\_  
DATE OF ANALYSIS: \_\_\_\_\_  
DATE OF HARVEST: \_\_\_\_\_

| Tree no. | 1       |      | 2       |      | 3       |      | 4       |      | 5       |      | 6       |      | 7       |      |
|----------|---------|------|---------|------|---------|------|---------|------|---------|------|---------|------|---------|------|
|          | Blemish | Cull | Blemish | Cull | Blemish | Cull | Blemish | Cull | Blemish | Cull | Blemish | Cull | Blemish | Cull |
| 1        |         |      |         |      |         |      |         |      |         |      |         |      |         |      |
| 2        |         |      |         |      |         |      |         |      |         |      |         |      |         |      |
| 3        |         |      |         |      |         |      |         |      |         |      |         |      |         |      |
| 4        |         |      |         |      |         |      |         |      |         |      |         |      |         |      |
| 5        |         |      |         |      |         |      |         |      |         |      |         |      |         |      |
| 6        |         |      |         |      |         |      |         |      |         |      |         |      |         |      |
| 7        |         |      |         |      |         |      |         |      |         |      |         |      |         |      |
| 8        |         |      |         |      |         |      |         |      |         |      |         |      |         |      |
| 9        |         |      |         |      |         |      |         |      |         |      |         |      |         |      |
| 10       |         |      |         |      |         |      |         |      |         |      |         |      |         |      |

**PEST / BLEMISH CODES:**

|                |              |                       |
|----------------|--------------|-----------------------|
| RS = red scale | Total<br>B C | T = thrips            |
| MB = mealybug  |              | LR = leafroller (tor) |
| BW = bollworm  |              | FCM = false codling   |
| BM = bud mite  |              | FF = fruit fly        |

ORCHARD: \_\_\_\_\_  
CULTIVAR: \_\_\_\_\_  
DATE OF ANALYSIS: \_\_\_\_\_  
DATE OF HARVEST: \_\_\_\_\_

| Tree no. | 1       |      | 2       |      | 3       |      | 4       |      |
|----------|---------|------|---------|------|---------|------|---------|------|
|          | Blemish | Cull | Blemish | Cull | Blemish | Cull | Blemish | Cull |
| 1        |         |      |         |      |         |      |         |      |
| 2        |         |      |         |      |         |      |         |      |
| 3        | T       |      | FF      | W    | BW      | NES  | —       |      |
| 4        |         |      |         |      |         |      |         |      |
| 5        |         |      |         |      |         |      |         |      |

**ES:**

|           |              |                          |              |          |
|-----------|--------------|--------------------------|--------------|----------|
| red scale | Total<br>B C | T = thrips               | Total<br>B C | W = win  |
| mealybug  |              | LR = leafroller (tor)    |              | C = cull |
| bollworm  |              | FCM = false codling moth |              | NES = r  |
| bud mite  |              | FF = fruit fly           |              | B = burr |

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# Integrated Pest Management for Citrus

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## 4 Interpreting Monitoring Results

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Learner Guide

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## information

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The first edition of the Integrated Pest Management for Citrus learner guides were exact transcripts of the audio-visual modules which they accompanied. This second edition has been updated with additional information and new developments. The changes are in italics and underlined.



## Introduction

A lot of information on pests and their natural enemies can be accumulated on the farm through execution of blemish factor analyses pre-harvest, through scouting, through trapping and through microscopic evaluations. But what does one do with this data?

It is the responsibility of the farm manager or the farmer to interpret this data and to use the interpretation of this data in the application of a pest management strategy.



## Tools for Interpretation

What are the tools for interpretation of this data? This data can be interpreted immediately on receipt of scouting and trapping data through:

- ❖ The use of **thresholds** where those exist for certain pests
- ❖ The use of Citrus Research International's **production guidelines**, which are very comprehensive for management of all important pests on citrus
- ❖ **Research results** which are generated. Each year, new results are coming through
- ❖ Fourthly, **technical recommendations** that come from experts in the area
- ❖ Fifthly, the **experience of experts** such as consultants
- ❖ Finally, your **own experience** as a farmer



## Preventative vs. Corrective Control

Before I move on to talking about decision-making on specific pests, I would like to sketch the difference between preventative pest control and corrective pest control.

**Preventative** pest control is control of the pest **before** it reaches the plant part on which it causes damage, usually the fruit.

**Corrective** pest control is only applying intervention against that pest **once it arrives** on the plant part on which it can cause damage.

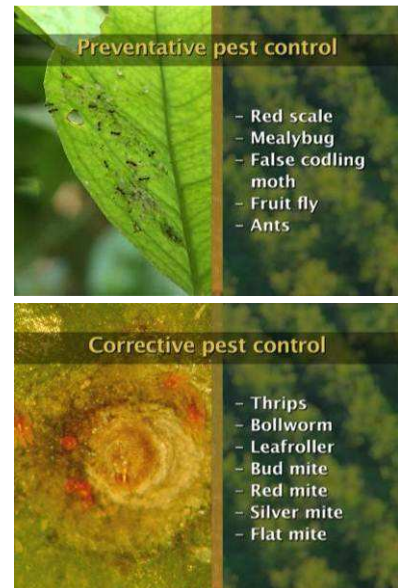


Pests which are most effectively controlled preventatively are insects such as:

- ❖ Red scale
- ❖ Mealybug
- ❖ False codling moth
- ❖ Fruit fly
- ❖ Ants

Pests which are most effectively controlled correctively are insects such as:

- ❖ Thrips
- ❖ Bollworm
- ❖ Leaf-rollers
- ❖ Bud mite
- ❖ Red mite
- ❖ Silver mite
- ❖ Flat mite



## Red Scale

### Pre-Harvest Blemish Analysis Data

As mentioned, red scale is by far more effectively controlled preventatively than correctively. Therefore, the decision about whether one needs to do anything for red scale control and what one should do should be made at the start of the season.

This would be based on a blemish factor analysis which is conducted at the end of the previous season.

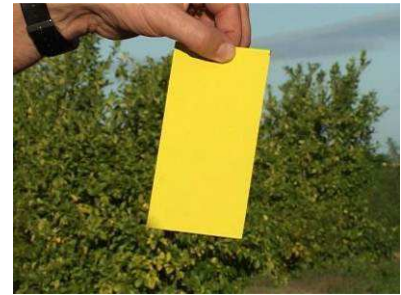
- ❖ If at harvest, between 0% and 5% of fruit are found to be infested with red scale, then a single treatment of whatever the grower's choice is, should suffice for controlling red scale
- ❖ If between 5% and 15% of fruit is infested at harvest, then two applications may be necessary
- ❖ If more than 15% of fruit are found to be infested with red scale at harvest, it may even be necessary to apply three treatments during the course of that season



## Trapping Data

In the module about pest monitoring we spoke about the possible use of yellow sticky traps with the use of a red scale pheromone for monitoring red scale numbers. We mentioned that these traps cannot be used for decision-making on whether it is necessary to intervene against red scale or not. Simply, they can be used for the timing of treatments against red scale.

These traps should be monitored weekly. Once a peak in flight numbers – or male numbers – has been determined with the use of these traps, then one can evaluate that within 240 day degrees after this peak there will be a crawler movement.

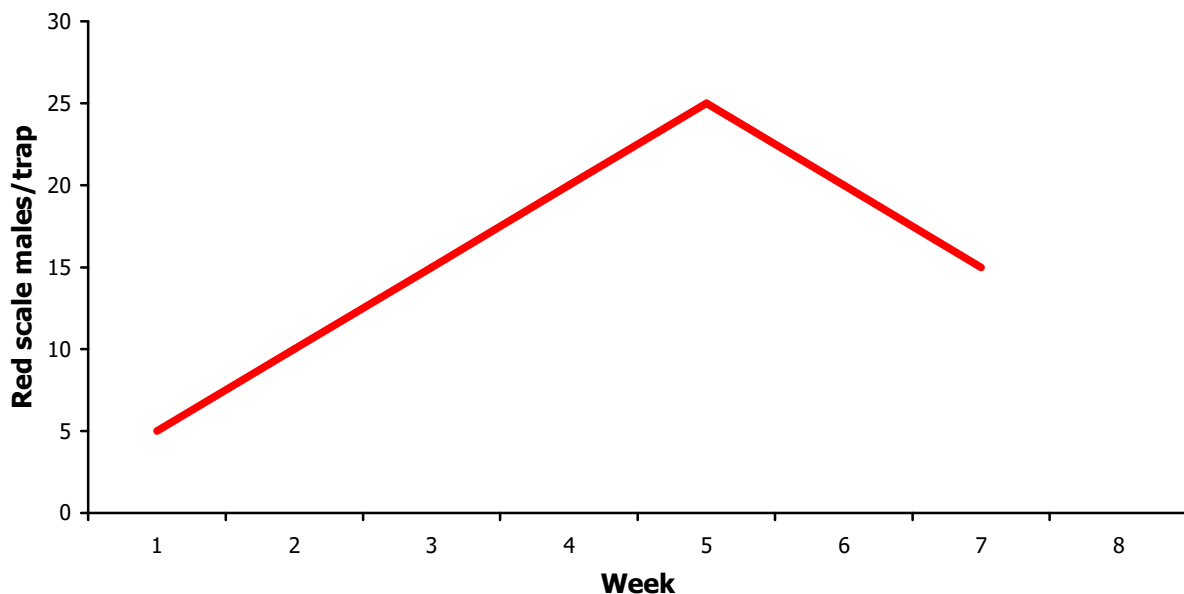


## information

### Flight Peak

Identifying a peak in male numbers is only possible a week or longer after the peak occurred, once the decline can be detected. Careful and regular monitoring is essential for this purpose, as is accurate recordkeeping of climatological data. If one determines today that there was a peak in male numbers 10 days ago, calculations need to be made using the temperatures for the last nine days.

Male numbers will build up and decline in a linear fashion, as in the example graph below:

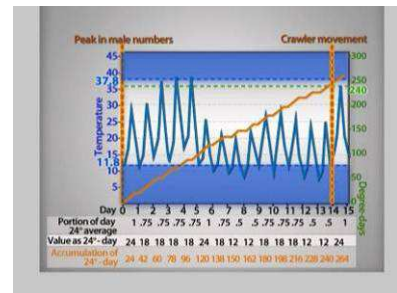
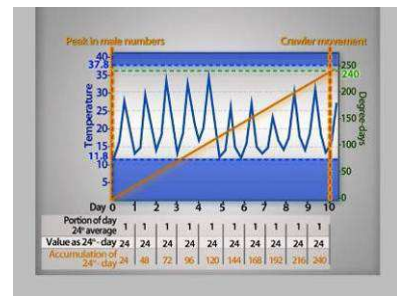


If one wants to spray an insect growth regulator like Buprofezin or Pyriproxyfen, or if one wants to release *Aphytis* parasitoids, then these should be timed against or shortly after a crawler movement.

In calculating these 240 degree days, it needs to be realised that red scale is inactive below temperatures of 11.8°C. Therefore, any hours during which the temperature was at 11.8°C or lower need to be deducted from the total making up those 240 degree days. Similarly, red scale is inactive at temperatures higher than 37.8°C, so any hours during which the temperature has exceeded this also need to be deducted from the final calculation.

To over simplify this calculation, if the average temperature for 10 days running was 24°C, then within 10 days after a flight peak on the trap, a crawler movement would begin.

Obviously in reality it is never quite this simple. Effectively it usually takes between two and six weeks after a red scale flight peak for crawlers to begin moving. This depends on the temperature at that time.



## Scouting and Microscopic Evaluations

Traps are valuable in helping to determine when sprays should be applied. It is even more important that red scale scouting is done in the orchards.

Red scale scouting data can be well supplemented with microscopic evaluations of red scale. Obviously a fairly good quality dissecting microscope is required and this will enable one to determine whether red scale is alive or dead, and if the red scale is parasitized and by what.

Such microscopic evaluations help one to determine whether the biological control of red scale is sufficient to bring it under control or whether chemical intervention is necessary, and it also helps one to gain familiarity with and confidence in the effectiveness of biological control complex.

On a regular basis, at least monthly, a well-infested sample of fruit should be collected from each orchard and inspected microscopically. This, one will do by using a sharp object, such as a pin, to lift up the scale covering of the red scale underneath the microscope and to observe and record what one finds underneath that scale covering, whether it is a live red scale, a dead red scale or a parasitoid, or whether the red scale was at one time previously parasitized.



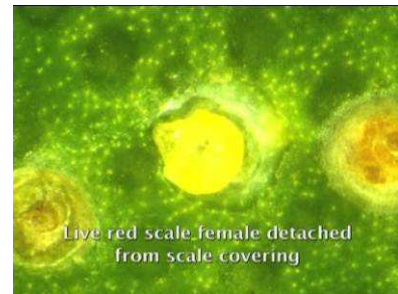
There are various symptoms which one can look for in identifying these different scenarios.

The first distinction that one needs to be able to make during a microscopic evaluation is between male and female insects. Male red scale insects are oval-shaped, while female insects are round. As a rule, microscopic evaluations should focus on female insects, purely for the sake of consistency.

After lifting the scale covering, you will be able to determine if the scale is alive, dead or parasitized. If it is alive, its soft body may either detach from the scale covering and remain on the surface of the fruit, or it may remain attached to the scale covering and come away from the surface of the fruit with the scale covering. This is the case if the insect is in the process of moulting.

If the red scale is dead it should appear emaciated or desiccated, as in this photo. You may also see a red scale insect that has been parasitized. This is what a red scale insect looks like that has been parasitized by *Aphytis*. Be careful not to confuse this with a male red scale, whose elongated body shape and black eyes may be mistaken for a parasitoid. If the *Aphytis* parasitoid has already emerged, you will see its residues.

The other form of parasitism that you may find is by *Comperiella bifasciata*. In this case, the red scale is almost entirely black in colour. Note the hole in each of the two scales on the right, through which the fully developed parasitoid has already emerged.



## Corrective Treatments

If the correct decision for red scale control has been made early in the season on whether a preventative spray should be applied or not, hopefully it will not be necessary at any stage later during the season to apply a corrective control measure. Nevertheless, by conducting this monitoring, both scouting in the orchards and microscopic evaluation, it will be possible to determine whether it is *indeed* ever necessary to apply a corrective measure late in the season.

Determining whether a corrective intervention is necessary for red scale or not, is very complicated. The grower needs to build up his own experience and his own history on his farm so that he can develop confidence in the ability of the bio-control complex on his farm.



Despite this complexity and variability, there are guidelines which one can use in helping to determine whether it is necessary to intervene correctively. These are based on red scale levels in the orchard and on parasitism levels which one observes microscopically.

As corrective intervention against red scale decreases in its effectiveness from February onwards, the latest that one would want to make a decision on whether it is necessary to intervene would be during February. In the hotter northern areas of the country this date at which one would make the decision on corrective *treatment* might even be as early as January.

These guidelines are for navel oranges. In February in the cooler Cape regions, *and probably in* January in the hotter northern regions *the following should apply*:

- ❖ Fewer than 40% of *fruit* should be infested with red scale
- ❖ At least 16% of the scale should be parasitized
- ❖ At least 50% of this parasitism should be by *Aphytis* species
- ❖ At least 30% of the scale should be dead
- ❖ In the cooler regions there should be a dramatic increase in the percentage of scale dead from January to February, and in the hotter northern regions a dramatic increase in mortality from December to January

If one considers that navel oranges on average are harvested in mid-May then with later hanging varieties, such as most Valencia types, one could make these threshold values slightly *more lenient* in February, and on earlier harvested varieties, such as most easy-peeler varieties, the threshold values would have to be slightly *more conservative*.



**Red scale corrective treatment**

- <40% navels infested
- >16% red scale parasitized
- >50% parasitized by *Aphytis* species
- >30% red scale dead

Increase in mortality

- Southern regions - January/February
- Northern regions - December/January

## Mealybug

### Preventative Treatments

As with red scale, mealybug is far more effectively controlled with preventative spraying than corrective spraying, therefore an early spray *is preferable*. The ideal timing for a mealybug spray is in spring, pretty

much synchronised with 100% petal drop.

There are three factors that need to be taken into consideration when deciding whether a preventative spray is necessary for mealybug or not. The first is based on the pre-harvest blemish analysis. If during this analysis conducted before harvest the previous season, any live mealybug is found on the fruit, under the calyx or in the navel-end, then a spring spray must be applied for mealybug.

The second is a winter and spring analysis. Here the trunks of trees and scaffolding branches need to be inspected for any presence of live mealybug, and as spring approaches, also the new flush and blossoms need to be inspected for any signs of mealybug. If any mealybug is found on these plant parts at these stages, then a spring spray for mealybug should be applied.

The third factor affecting one's decision-making, is the spray programme which has been chosen for the remainder of the season. If any sprays are planned which can be disruptive to the natural enemies of mealybug, then a spring spray for mealybug should be applied.



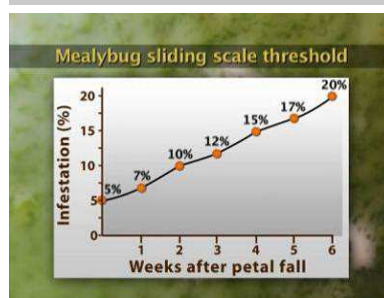
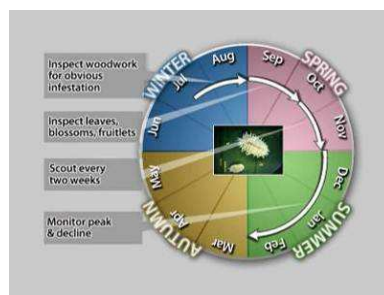
## Scouting Data

Now regardless of whether one has applied a preventative spray for mealybug or not, it is essential that regular weekly scouting is conducted from 100% petal fall for the following six weeks.

It cannot simply be assumed that because a spring spray has been applied, mealybug is now under good control. There are various reasons which could lead to a failure or an inadequacy of an early spring spray.

From petal fall until six weeks later, there is a sliding scale threshold which can be applied.

- ❖ If at 100% petal fall 5% or more of fruit are found to be infested with mealybug, a spray should be applied
- ❖ A week later, if 7% are infested a spray should be applied,
- ❖ Two weeks later, 10%,
- ❖ Three weeks after petal fall, 12%,
- ❖ Four weeks after petal fall, 15%,



- ❖ Five weeks after petal fall, 17%, and
- ❖ Six weeks after petal fall, 20%

Thereafter the frequency of scouting can be reduced to once every two weeks. It is very important to continue this regular scouting.

Mealybug infestation normally will continue to increase during the season, even if a spray has been applied. Mealybug will *normally* peak in the northern areas in December, and in the southern cooler areas, normally in January. Thereafter there should be a dramatic decline in mealybug levels. If within a month after that there hasn't been a conspicuous decline in mealybug levels, one should seriously consider the application of a corrective spray for mealybug.



## Corrective Treatments

### Life-Stages

If one decides that it is necessary to apply a corrective spray for mealybug and the product of choice is an insect growth regulator, then the timing of the spray is very important. Insect growth regulators for mealybug are only effective during the younger life-stages.

It might therefore be necessary to pick a sample of mealybug-infested fruit and to assess it microscopically. One then needs to ensure that the majority of mealybug is in the younger life-stages, either as egg sacs or as crawlers. If the majority is not yet in the correct life-stage then the grower should wait for another week or two before reassessing the situation and possibly applying the spray.



Citrus mealybug adults and crawlers



Citrus mealybug with egg sac

### Ant Control

Another important factor to take into consideration before one decides whether it is necessary to apply a corrective spray for mealybug or not, is ant control.

Mealybug has a very effective natural enemy complex; however, this is significantly disrupted through ant activity. Therefore the grower should check the scout's results and ensure that there is not unacceptable ant activity in the orchard.



The first thing that needs to be done before a spray is applied for mealybug is to bring this ant activity under control.

## Mealybug Species

Sometimes it is also important for the grower to determine what species of mealybug are infesting his fruit. This could be for one of two reasons. If the grower is considering releasing parasitoids for mealybug control, such as *Coccidoxenoides perminutus*, these parasitoids are only effective against citrus mealybug. The presence of any other mealybug species therefore needs to be discounted before the grower decides to release this parasitoid. *Anagyrus appears to have a slightly broader host range; however, full clarity on this must still be established.*

The second important consideration in talking about mealybug species is that certain markets recognise some of the mealybug species that occurs on citrus in South Africa as quarantine or phytosanitary pests. If one is sending fruit to one of these sensitive markets, one also needs to make sure that none of these unacceptable species of mealybug occur on the fruit.



Karoo thorn mealybug



Citrus mealybug with egg sac

## Thrips

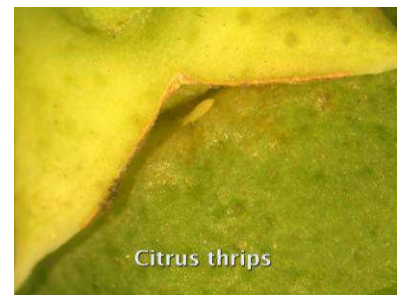
### Preventative Treatments

Thrips is normally controlled correctively and such control measures are normally satisfactory for thrips. However, a preventative application can be made early in the season before blossom on the new spring flush.

Although only leaves will be damaged at this stage, knocking down thrips levels, which should be well synchronised with the early spring flush, should lead to lower levels of thrips appearing on the fruit once they set.

There are two ways in which one can decide whether a pre-blossom application on this flush is necessary or not. This can be done by the scout inspecting the flush in spring and if any infestation or damage on this flush is noted, a spray can be applied, or this can be done through the use of sticky yellow card traps.

If card traps are used and any citrus thrips are caught on these traps during this time of spring flush, then an application can be made on this spring flush.



Citrus thrips





## Corrective Treatments

However, if these traps are used during blossom or after blossom has dropped off the tree, then a threshold applies to the thrips numbers that are caught on these traps.

It is also very important to differentiate between male and female thrips and to identify the species of thrips. There are more than just citrus thrips which are attracted to these traps, particularly blossom thrips and onion thrips, and one needs to be able to differentiate these from citrus thrips.

For this one needs a good microscope; however, to the trained eye a good magnifying glass may be sufficient to identify thrips accurately on the yellow card traps.

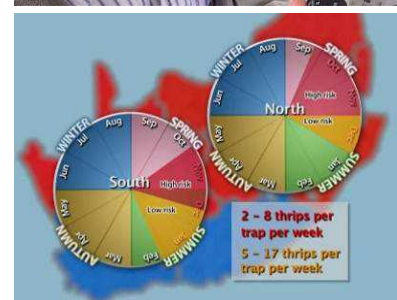
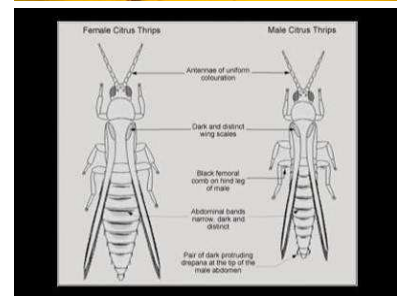
Thresholds on traps differ from region to region and also differ during the high risk period and the low risk period. This is the period when fruit is highly susceptible to thrips damage and the period after which the fruit is no longer as susceptible to thrips damage.

This high risk period in the northern areas runs until the end of November and in the southern areas until the middle of December. The low risk period for thrips damage in the northern areas runs to the end of December and in the cooler southern areas until the first week in February.

The threshold which is used differs during the high risk period and the low risk period. During the high risk period, an average of between two and eight thrips per trap per week would indicate the necessity to spray.

During the low risk period, an average of between five and seventeen thrips per trap per week would indicate the need to spray. However, for the more exact thresholds, which apply to your region, you should consult the CRI IPM production guidelines

Although the use of yellow sticky traps is very valuable, unfortunately the use of these traps alone is not very accurate. One needs to rely very heavily on the



information generated by visual scouting on the fruit conducted by the trained scouts.

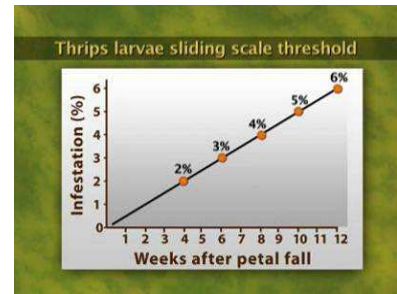
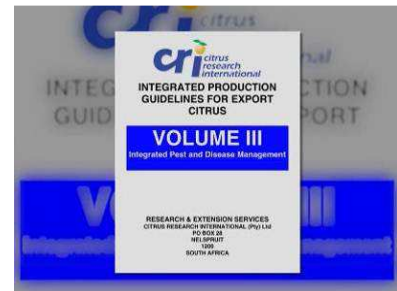
Here the scout needs to differentiate between the adults and larvae of thrips and there are fairly intricate thresholds which apply to both life-stages or a combination of both.

I will outline only those thresholds which apply to thrips larvae here as this is the most damaging life-stage of thrips.

- ❖ From petal fall to four weeks, a 2% infestation of thrips on fruit indicates the need to spray immediately,
- ❖ From five to six weeks, 3%,
- ❖ From seven to eight weeks, 4%,
- ❖ From nine to 10 weeks, 5%, and
- ❖ From 11 to 12 weeks, 6%

Any thrips infestation thereafter, which will lead to unacceptable damage, would have to be higher than a 6% level.

Scouts should also inspect for predacious mites in the way in which they have been trained to do. Presentation of this information to the grower will also help in mitigating the risk of mid-season thrips infestations and increase the probability that a spray would not be necessary late in the season.



## False Codling Moth

### Trapping Data

Traps used to be used for threshold purposes for false codling moth, i.e. for determining whether it is necessary to spray for false codling moth or not.

However this is not the case anymore. The pest status of false codling moth has reached a level where intervention is always necessary, even if levels are low.

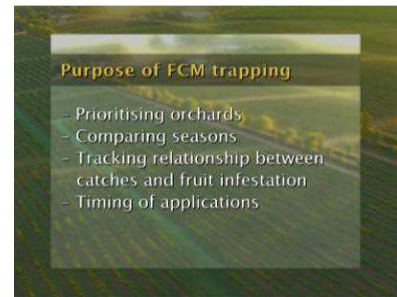
Traps are used for:

- ❖ Comparing FCM levels between orchards and therefore prioritising intervention in particular orchards



- ❖ Comparing one season with another
- ❖ Trying to establish a relationship between moth catches and fruit infestation
- ❖ Accurate timing of virus sprays – if a virus is going to be sprayed in that orchard for FCM control, it should be applied approximately one and a half weeks after a peak in FCM catches.

If it is found that there is no relationship between trap catches and fruit infestation, this could be a sign that the traps are incorrectly positioned. Traps should therefore be repositioned according to the recommendation, which come with the trap or which appears in the CRI production guidelines, or the trap may need to be moved to a completely different position in the orchard. Remember, however, that if FCM levels are low and it is difficult to detect any peak in either fruit infestation or moth numbers, it would be near impossible to try and establish a relationship between the two.



## Fruit Infestation Data

Each week your scout would also provide you with fruit infestation data. This data will tell you three things:

- ❖ It will tell you how well your FCM is being controlled
- ❖ It will give you an indication of whether it is necessary to apply any further measures for FCM control
- ❖ Most importantly, it will speak to the postharvest risk of fruit coming from that orchard

There is no universal threshold for fruit infestation. Because FCM is a phytosanitary pest, one should strive to bring infestation levels to as close to zero as possible. However, the sensitivity of the particular market to which the fruit is being sent will dictate what can be tolerated in the orchard and what makes that fruit unsuitable for a particular market or not. *An average of no more than 0.2 infested fruit per tree per week can be used as a benchmark for the maximum acceptable.*



## Egg Parasitism Data

Your scout may also provide you with figures for FCM egg numbers on fruit and for parasitism levels of these eggs.

Although this information cannot be directly used in decision-making, the level of parasitism is a very good indication that this parasitoid will play a significant role in suppressing FCM levels and prevent an upturn in FCM infestation towards harvest.

Ideally one would want to see in excess of 80% of eggs parasitized.



## Fruit Fly

### Trapping

Fruit fly trapping should begin before colour break. Colour break is initiated approximately two months before projected harvest date.

From this time, a routine fruit fly control programme must be employed, regardless of whether anything has been caught in the traps or not. The sole purpose of the traps is to dictate whether additional applications of the treatments must be applied or not.

Capilure loaded traps catch predominantly male flies. The thresholds which apply for Mediterranean fruit fly and Natal fruit fly differ. Therefore the scout or the farmer needs to differentiate between these species. A good magnifying glass is sufficient to do this.

For Mediterranean fruit fly, it would be four flies per trap per week. For Natal fruit fly, it would be two flies per trap per week. Any catch that meets or exceeds these thresholds would mean an additional weekly application would be required, until numbers again drop below this threshold level.

Questlure loaded traps catch predominantly females. The threshold here is the same for both Mediterranean and Natal fly and is one fruit fly per trap per week.

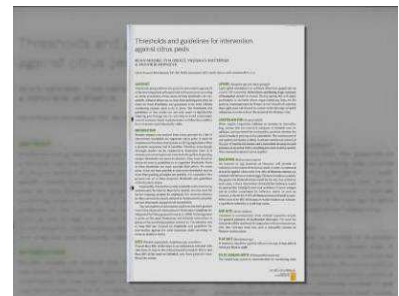
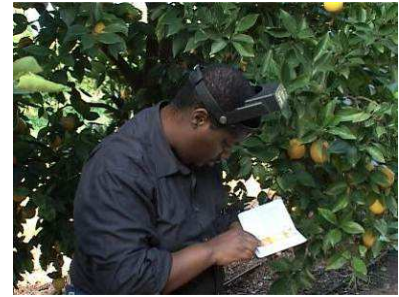
*The threshold for Oriental fruit fly is three flies per trap loaded with methyl eugenol per week.*



## Other Citrus Pests

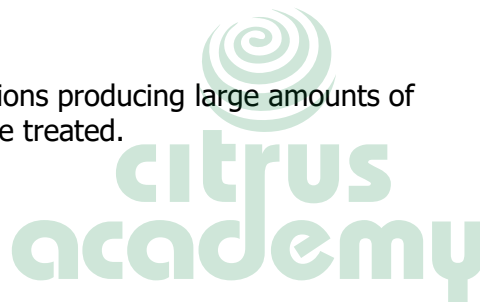
For many of the other citrus pests, there exist specific thresholds for intervention, for others, there are simply guiding principles to help one in that decision-making process. However, what both of these assume is that there is a reliable and accurate and regular monitoring system in place to generate data that can be used.

All of these specific thresholds and guidelines are given in the scouting book which is provided by CRI and they are provided in an article which was written up in 2008 for the South African Fruit Journal. However, I will cover now some of the thresholds and guidelines for some of the important pests which haven't already been mentioned.



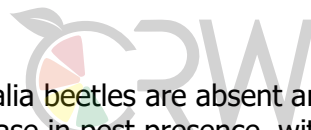
### Aphids

For aphids, infestations producing large amounts of honeydew should be treated.



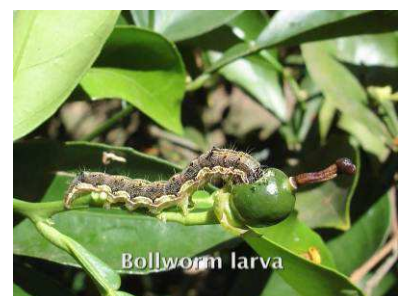
### Australian Bug

For Australian bug, if Vedalia beetles are absent and there is a noticeable increase in pest presence, with a resulting increase in sooty mould, then intervention is required.



### Bollworm

For bollworm, if 20% of blossom or fruitlet clusters are infested with any life-stage, then a spray should be applied. If it is an orchard of navel oranges with a particular problem with enlarged navel-ends, this threshold can be brought down to 11% infestation.



### Bud Mite

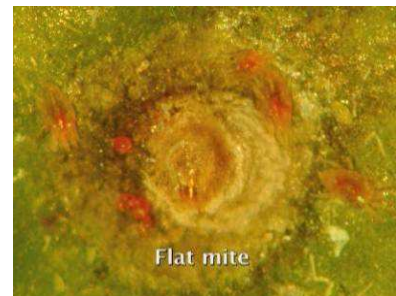
For bud-mite, if there is a general presence of

malformed blossoms, certainly not more than 10% of blossoms, then a spray should be applied.



## Flat Mite

For flat mite, if one mite or more are recorded per fruit or stalk then a spray is necessary.



## Leafhoppers

For leafhoppers or planthoppers, traps are used for monitoring. For the brown citrus leafhopper the threshold is 35 to 40 leafhoppers per trap per week. For green leafhoppers it is in the region of eight per trap per week.



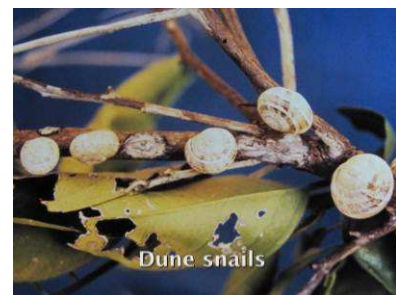
## Planthoppers

For planthoppers there is no threshold, however if there is a general build-up of the pests associated with sooty mould, a spray will be required.



## Snails and Slugs

For snails and slugs, an average of from two to five brown or dune snails or slugs per tree, depending on tree size, indicates a necessity to treat for these.



## Soft Scales

For soft scales, that is soft green scale or soft brown scale, treatments must be applied to ensure that a build-up of sooty mould does not inhibit tree performance or cause fruit drop.



## Waxy Scales

For waxy scale, the fairly general presence of infested twigs on trees can be regarded as a potential infestation hazard requiring treatment.



## Red Mite

For red mite, a spray should be applied when an average density of five adult mites are noted per leaf.



## Conclusion

If there are any pests and thresholds which have not been covered in this material, please consult the CRI production guidelines for IPM volume III or consult the CRI scouting manual.