Managing plant pathogens and insect pests in slipper orchids

The orchid sub-family Cypripedioideae that includes the genera Paphiopedilum, Phragmipedium and the lesser known and seen in local collections, Mexipedium, Selenepedium and Cypripedium orchids is fortunately less susceptible to orchid pathogens and insect pests than many of the other exotic genera that we grow.

However, there are fungal and bacterial pathogens that can cause devastating losses to our collections, even though there are often relatively simple and inexpensive means to combat these diseases. In this regard, “good culture” is the single most important factor in ensuring that your orchid collection is healthy. During our discussion, I will highlight some of the elements of culture that we all know well, but often overlook. Forgive me for ‘do as I say, not as I do!’ As a study group, we have spent considerable discussion time sharing our thoughts about ‘broad cultural practice’ so I will only cover this aspect in general terms.

In general, my experience and research indicates that slipper orchids that are not lost through poor culture are most often infected by fungal or bacterial infection that may be transmitted from one plant to another via cutting instruments and water splash, or from recycling pots that have not been adequately sterilised. As part of good cultural practice, media pot sterilisation is simple and inexpensive. 10ml of liquid pool chlorine per litre of water and soaking pots for 24 hours before rinsing clean will eliminate the majority of viral, bacterial and fungal pathogens of concern (assuming that used pots are scrubbed prior to this treatment – in my view any that do not come clean should be discarded). I use pool chlorine as it is cheap and effective and is generally 125 gm/l whereas household bleach is only half this strength. Therefore, if you are using household bleach, you will need to double the concentration. Media sterilisation using the same technique will eliminate slug and snail eggs and undesirable thread and similar fungal pathogens.

What my research has very clearly shown however that it is difficult, if not impossible for us as hobbyists to differentiate between many of these pathogens. Consequently, we need to be prepared to switch to another remedy if the one we are using is not working.

The other basic procedure in managing disease is the isolation of infected plants, either by their removal from your growing area, or at the very least, if this is not possible, substantial separation from similar genera.
Viral Pathogens of Orchids

Fortuitously, viral pathogens seem to be less of a problem for slipper orchids than many other genera, although infections are reported and good plant husbandry and sound hygienic practice can reduce the risk. What makes viral infections more difficult to manage in *Cypripedioideae* is that generally, the virus is not expressed in an easily recognised visual form such as leaf markings or a colour break in the flower.

The most common viruses that infect orchids, specifically Mosaic Virus (TMV) and Odontoglossum Ringspot Virus (ORSV) are generally transmitted from plant to plant by physical means such as secateurs or other cutting instruments (in this context, viral pathogens are able to survive for more than a week in dried plant sap) or by use of previously contaminated pots leading to sap exchange and a transfer of infection. Inadequate general hygiene practice can also allow plant-to-plant sap exchange.

The research conducted for this paper found scant published material on viruses affecting slipper orchids, however there seems to be some evidence that TMV, ORSV, Bean Yellow Mosaic Virus (BYMV), and more recently Orchid Fleck Virus (OFV) can infect *Paphiopedilum* and *Phragmipedium*. As an aside, OFV has been found in local orchid collections, but is much more difficult to positively identify as the popular and inexpensive virus test kits which identify the Potyvirus specific monoclonal antibody cannot test for this virus. Some of the reports that I read indicate that virus infection is more common in *Phragmipedium* than *Paphiopedilum*, and is most often attributable to poor hygiene in a mixed collection of orchids, and associated with older clones that have been passed from grower to grower. Another reason that infection rates tend to be lower than with other orchids is that slipper orchids are rarely divided by cutting with a sharp instrument, but are simply broken apart, or allowed to fall apart on their own.

By and large, once a plant has been infected by a viral pathogen, there is little that can be done to control the disease and save the plant. Put simply, dispose of the plant safely - this is most likely to be by placing it in the local council bin, but you could also burn the plant once it has dried off; if doing so ensure that it is stored well away from the other orchids in your collection while it is drying to minimise the risk of cross-contamination.

Good hygienic practice should help avoid any virus infection. Sodium hypochlorite (NaOCl) at 10% solution for a minimum of 5 minutes was found to be effective in inactivating TMV and ORSV, and presumably BYMV. While I was not able to find details of treatments for disinfecting cutting instruments or pots where Orchid Fleck or Orchid Streak virus (rhabdovirus) is suspected, it is reasonable to assume that a strong NaOCl solution (at least 10%) might also be effective in inactivating the virus provided adequate exposure time was allowed. Other products like trisodium phosphate are ineffective at concentrations below 5%, and that it needs to be at least 10% solution for more than 5 minutes to inactivate virus.

However, the major reason that we tend to overlook these requirements is the time taken to sterilise cutting instruments when we are short of time, or need to use them over again in a short space of time. I was unable to find any contemporary research about more rapid methods of inactivating virus, so for the time being caution is likely to be the best guide, and consequently, the approaches outlined above, notwithstanding the time constraints should be followed. However, if you have high quality cutting instruments, flaming to red heat with small blow torch is effective, but will over time damage the cutting blades. Another option is single use scalpel blades that are discarded after use on a single plant.
Bacterial Pathogens of Slipper Orchids

There are many thousands of bacterial pathogens that exist in the general environment in which we live, however one of the most persistent and damaging to *Paphiopedilum* orchids are members of the *Erwinea* group. These bacteria can be particularly hard to control and rapidly lead to the death of even large plants as slipper orchids seem to be highly susceptible to this pathogen.

In this regard, it should be remembered that bacterial pathogens are considerably more difficult to control than fungal pathogens, and more often fatal to the plant. Pool chlorine (NaOCl) at 0.5% concentration (50 ml in 10 litres of water) has been found to be effective as a pot drench (although a much stronger solution is required for sterilising cutting and other instruments).

Brown Rot

*Erwinia* is a particularly damaging bacterial pathogen that can quickly spread through different genera in an orchid collection, leading to the death of many plants before eradication. As noted in an earlier part of the article, sterilising media and pots before use with pool chlorine (NaOCl) can help minimise outbreaks, and drenching plants with a 5ml/litre solution can help prevent the spread of infection once it is present. This should be accompanied by cover-spraying the walls, roof, floor and benches with a 10% NaOCl solution to kill any spores present.

Erwinea sp on *Paphiopedilum* plants.
Photo source: [http://staugorchidsociety.org/culturepests-diseases-erwinia.htm](http://staugorchidsociety.org/culturepests-diseases-erwinia.htm)

My research uncovered substantial research carried out in the US dealing with *Erwinia* soft blight infections in *Paphiopedilum*, and in commercial horticulture, for *Oncidium* and *Phalaenopsis*. In the published results, the products that consistently achieved acceptable results were Kocide 300 ® (sold in Australia as Kocide Blue Extra®) and Kleen Grow® from PACE 49. The latter product is not available in Australia, but its active ingredient, Didecyl Dimethyl Ammonium Chloride is found in a range of products including Pool Magic No Metal Algae Killer® (which also includes the active ingredient in Alginox®, Benzalkonium Chloride) and Agricrop Steri-Max Biocide®. These products are relatively inexpensive and Kocide Blue Extra® can be purchased in small quantities from Bunnings (30g for less than $10), or 10kg from suppliers including Mirco Bros at approximately $130. In the past, The Paphiopedilum Study Group purchased Kocide Blue Extra and distributed smaller quantities to members.

The most common bacterial infection in our slipper orchids is likely to be *Erwinia cypripedii*. This disease generally enters the plant through a wound on the leaf or roots. On the leaf it starts as a small brown spot or across a cracked leaf and spreads in both directions so that it eventually reaches the crown of the plant, before spreading to the next leaf and so on until the whole growth is affected. Even new growths from the crown can be affected and turn brown and die. Often, the whole crown is affected and turns brown while the outer ends of the leaves remain green. In this instance, unless there are multiple growths with others unaffected, the plant cannot be saved. However, if caught in the early stages the leaf can be cut below the infection so that clean tissue is
left, or by removing the infected section. The plant then needs to be soaked for several hours in fungicide and repeated 2-3 times every three to four days to ensure that the disease does not revive. Following treatment, the foliage should be kept dry with watering applied carefully to avoid any splash onto the leaves. Treatment with a systemic fungicide such as Fongarid™ every three months can be an effective deterrent, keeping in mind the need to rotate fungicides in order to minimise development of resistance.

**Bacterial Brown Spot**

Bacterial Brown Spot is an infection caused by the bacteria *Acidovorax* (syn. *Pseudomonas*). The symptoms may appear anywhere on the leaf as a small, soft, water-soaked blister. Initially dirty green in colour, the infected spot enlarges, coalesces and eventually becomes brown or black, dried up and sunken. It oozes bacteria-laden liquid. It is highly contagious and can spread rapidly through a collection.

Treatment for *Pseudomonas* involves killing the bacterium, and preventing reinfection by rectifying the environmental conditions that allowed it to gain a foothold in the first place. While localised infection may be treated with hydrogen peroxide (H₂O₂), infected leaf tissue should be carefully removed. In view of our experience, I recommend treatment with NaOCl as for *Erwinea*.

It is very important to apply preventative treatment to adjacent plants as this disease is rapidly spread by water splash. Alginox® should take care of this, or a copper-based fungicide such as Kocide Blue Extra®, Yates Liquid Copper®, or products containing Copper oxychloride as an active ingredient can be applied to plants, benching, wall/floor/roof surfaces as a prophylactic. Environmental control is managed through increased air movement so that plant leaves are not wet for extended periods of time during the daylight hours, or overnight.

There may also be opportunities to use beneficial bacteria such as *Trichoderma harzianum* or *Bacillus subtilis* on young plants to build resistance to harmful bacteria. These organisms are antagonists, that is, they form deposits at the roots of the orchids and make them more resistant to harmful fungi.

**Oomycetes and Fungal Pathogens of Slipper Orchids**

Fortunately, genera in the orchid sub-family *Cypripedioideae* appear to be less susceptible to this group of pathogens than many of the other genera that we grow, and are more simply controlled.

**Black and Brown Rots**

Black rots in orchids are due to many pathogens, both fungal or close relatives and others by bacteria such as *Erwinea*. The water moulds, *Phytophthora* and *Pythium* are often loosely referred to as fungal pathogens but are in fact protists or Oomycetes (one-celled organisms).

More than 60 species of *Phytophthora* are recognised and most are pathogenic. These commonly called water mould infections are responsible for Black Rot, Crown Rot and Damping-Off in orchids with the symptoms being the rapid disintegration of tissue once the plant is infected. Main species found on Orchids are *Phytophthora cactorum* Schroet., *Pythium ultimum* Trow., *Pythium debaryanum* Hesse and *Pythium splendens* Braun.

Infection of mature *Paphiopedilum* plants generally presents as brown to black infested areas on the leaf base and rhizomes. Over time, the infested plant parts rot
away and finally the plants die. The disease usually occurs as a result of inadequate attention to culture when ideal infection conditions of high humidity and high temperature occur in our summer months.

Often the first signs of infection are water-soaked spots on leaves that rapidly expand and turn brown or black before progressing to the roots leading to plant mortality. It can also affect orchid roots and crowns appearing as necrotic lesions that eventually defoliate the orchid.

What distinguishes these black rots from fungal pathogens such as *Glomerella* is that the lesions are soft and uniform in appearance, have no defined rings or lines of fruiting bodies. However, it is almost impossible to distinguish infections caused by *Phytophthora* from those caused by the bacterial pathogens *Pseudomonas* and *Erwinia* that also cause diseases commonly called 'black rots'. All produce water-soaked lesions that do not show any fruiting bodies, all spread rapidly, and can be similar in colour. The one distinguishing feature is that the liquid from the bacterial lesions such as Erwinea have a very offensive smell.

*Pythium* occurs at or below the surface of the medium, and leaves are rarely infected. The infection starts in the roots or rhizome and progresses up the pseudobulb as a soft brown rot that has a clearly defined border.


This infection is most often seen in newly deflasked plants which ‘damp-off’ with a soft brown rot that affects the stem where it enters the media, but can also affect mature plants in poorly drained or stale media. As is the case with *Phytophthora*, there are no obvious fruiting bodies distinguishing this infection from those caused by other root-rot pathogens such as *Rhizoctonia* that causes hard, dry, brown bases of the pseudobulbs. While it is less pathogenic than *Phytophthora*, *Pythium* can still have equally devastating effects.

While the best method of dealing with these pathogens is to manage your growing environment well, from time-to-time, these diseases can be present and need to be confronted. The zoospores of both are readily spread by water splash, so the infection can rapidly spread from plant to plant. Therefore, your first action should be the removal of infected plants from the general collection to minimise the spread of the disease. These plants should be treated and isolated until there are no further signs of disease before being returned.

*Phytophthora* can be treated using a product such as Alginox ® in which the active ingredient is Benzalkonium chloride. This product is widely sold as swimming pool algaecide, and is relatively cheap when compared with many of the commercial fungicides. While it was not prepared for use on orchids, it has been shown to be effective, and can be applied at the rate of 15 ml per 4 litres of water. If the infection is well established, the plant should be removed from the media and immersed for 10 minutes. Following this, remove all the dead/damaged plant material and re-immerser in a freshly made solution for a further 10 minutes.

By the time an infected plant is noticed, spores will have infected neighbouring plants, therefore some action is necessary to control of this pathogen. This can be achieved by drenching with Aliette ® WG systemic fungicide from Bayer Cropscience at the rate of 90g/100l of water at 6 week intervals. The active ingredient in this
product is 800 g/kg Fosetyl Aluminium. However, this product is expensive and is not readily available at the local hardware shop or nursery (although Mirco Bros and several on-line suppliers do list it at $93 per kg). A broadly similar product, Yates Anti-Rot® which contains a phosphonate, Potassium phosphite as its active ingredient may be just as effective and is available from Bunnings and relatively inexpensive at less than $20 for 500ml.

Contact fungicides such as Mancozeb are ineffective against these pathogens, while copper-based fungicides including copper oxychloride or Kocide Blue® kill the spores and do provide some protection against initial infection, but have no curative effect once the disease is established (however, their repeated use may lead to phytotoxic effects particularly in some of the Dendrobiums). Ridomil® is effective against *Phytophthora*, and is more effective than Aliette® WG against *Pythium* (Ridomil Gold® in which the active ingredients are Mancozeb® and a small proportion of metalaxyl is available from specialist suppliers, but is quite expensive at $195 for 5 kg). Fongarid® controls both and has both protective and curative properties (Fongarid is available from Bunnings at $17 for 10gm). All three of these fungicides have a systemic effect and may control both *Phytophthora* and *Pythium* for up to 6 weeks after treatment.

**Root Rot**

Root rot due to *Rhizoctonia* is another common fungal infection which debilitates the roots and in due course, the leaves. The most common pathogen, *Rhizoctonia solani* does not form any spores, but only dense mycelium settling on organic material. When the plants are more infested, there will be curling, usually at the roots. The fungus is widely spread and often gets into orchid cultivations in substrates. Wet, cold and badly ventilated substrates help the organisms to spread. In substrate, *Rhizoctonia* may form persistent sclerotial diseases which may be infectious for a very long time.

![Paphiopedilum plant with roots affected by Rhizoctonia solani](image)


This root rot generally occurs when the medium breaks down, drainage is poor and/or plants are overwatered. It can also infect your orchid when roots are damaged by mechanical injury, salt build-up or over fertilizing. It is highly contagious disease and if not immediately controlled, orchid plants develop brown root rot and die. If you are using scheme or ground water on your orchids, heavy and less frequent watering with regular heavy flushing will help limit the build-up of harmful salts that can be seen as a white crust on the media surface, or around the drain holes of the pot.
Rhizoctonia infection in Paphiopedilum

Photo source: http://hark-orchideen.com/CD/EN/Pflanzenschutz/Rhizoctonia/print.html

As said, Rhizoctonia is primarily a root disease although the symptoms can be observed on aerial parts of the plant as leaves and pseudobulbs become yellow, desiccated, thin and twisted and/or new growths become progressively smaller. Closer examination of the orchid roots will reveal a brown rot with white or brown fungal growth. In severe infections, this pathogen girdles and kills the plant.

Rhizoctonia is also a major source of plant loss in orchid seedlings as it rapidly invades the lower leaves and rhizomes of small seedlings (it is another one of the spectrum of pathogens loosely referred to as “damping off”). If possible, any roots and leaves infected should be removed and the plant immersed in a protectant fungicide such as Ridomill Gold WP ®. The growing area should be disinfected with a 10% NaOCl solution. This pathogen can be one of the silent killers as unless leaves become infected or the plant becomes visibly distressed, it cannot be seen. Therefore, regular repotting with sterilised media should form part of the protective regime to limit the impact of this disease.

Tropical Fungi

The topical fungi such as Anthracnose, Cercospora, Glomerella and Gloeosporium are generally not threatening to the life of the plant, but cause unsightly markings on the surface of the leaves and measures should be taken to prevent their development. Anthracnose is a fungal infection which usually affects the air borne parts of the plant, mostly the leaves.

In order to treat this infection, it is important that to apply both protectant and systemic fungicide alternately to the entire plant. These pathogens proliferate in warm and humid environments when there is not enough light or air movement. If one of the plants in the growing area is infected then it is important to improve the air flow, increase the amount of light and lower the temperatures in the entire area to avoid the disease spreading.

Glomerella (Anthracnose) on Paphiopedilum

Photo Source
http://www.parramattaorchidsociety.org/Major%20Fungal%20and%20Virus%20Diseases%20Orchids%20PDOS.pdf
While these pathogens are more often unsightly rather than fatal to the plant, an Anthracnose infection in a *Paphiopedilum* can lead to the loss of the plant. My research indicates that Octave® is an effective fungicide to treat this unsightly and damaging pathogen. It is applied at 1 gm/litre of Octave® and 2 gm/litre of Mancozeb® ensuring complete coverage on both sides of the leaves with runoff through the media.

*Anthracnose on Paphiopedilum*, caused by *Colletotrichum gloeosporioides*


These pathogens are more prevalent under the conditions in which other rots develop. Attention to the physical conditions including frequency of watering, adequacy of air movement, temperature control and spacing of the plants, together with alternate monthly prophylactic spraying with fungicides such as Mancozeb®, Zineb® at the season change danger periods where changes in humidity and temperature can encourage these pathogens.

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<td>Product</td>
<td>Treatment</td>
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<td>NaOCl</td>
<td>5ml/l as a drench Prophylactic spray as per manufacturer’s advice for ornamentals</td>
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<tr>
<td>Bacterial Brown Spot (<em>Pseudomonas</em>)</td>
<td>Alginox, Kocide, Blue Extra, Yates Liquid Copper</td>
<td>15ml/4l as a drench Other products as per manufacturer’s instruction for ornamental plants</td>
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<td>Crown &amp; Root Rot (<em>Rhizoctonia</em>)</td>
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<td>15ml/4l as a drench 5ml/l as a drench Manufacturer’s recommended rate for ornamentals</td>
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<td>Tropical Fungi (<em>Anthracnose, Cercospora, Glomerella</em> and <em>Gloeosporium</em>)</td>
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New directions for control of plant pathogens

During my research for this article, I came across information about the use of biological and quasi-biological control products used in the US to deal with brown rot of *Paphiopedilum*. I have not used any of these products so cannot provide any information based on personal experience and therefore provide only that which is published and seems to have multiple author support.

The first non-chemical control that I discovered is use of ‘beneficial’ fungi, *Trichoderma sp.* In the US, a product Root Shield® is actively marketed to orchid hobbyists and professionals as part of a preventative treatment regime designed to develop plant resistance to a wide range of orchid pathogens. For example, this fungi is reported to inhibit the growth and spread of fungal pathogens including *Botrytis, Fusarium, Phytophthora, Pythium*, and *Rhizoctonia*. In his book, *Understanding Orchids: An Uncomplicated Guide to Growing the World’s Most Exotic Plants* (2004), William Cullina strongly promotes the use of beneficial insects and biological plant pathogen controls as a more sustainable way of growing orchids that is less damaging to the fragile environment in which we live.


In Australia, a product Tricho-Shield™ available from Nutri-Tech Solutions in Queensland is a talc-based formulation containing the beneficial fungal species *Trichoderma harzianum, Trichoderma lignorum* and *Trichoderma koningii* which the manufacturer claims promotes plant and root growth, and helps ornamental plants develop resistance to fungal and bacterial pathogens. This product is quite expensive ($53 per kg) and has a relatively short shelf-life (3 months), along with refrigerated storage requirements.

Another US product in this arena is Cease® a foliar spray which has *Bacillus subtilis* as its active ingredient. This product is claimed to be effective against *Botrytis, Erwinea* and *Pseudomonas*. I found a range of broadly similar products available on-line from Plant Health Solutions .com.au although these too are expensive at $66 and up for amounts as little as 250gm.

Another Australian product SPOREKIL® is said to be environmentally friendly while helping control fungi, bacteria and it is claimed, certain viruses. The active ingredient is Didecyldimethyl-Ammoniumchloride. This product should more correctly be described as an agricultural disinfectant, but is reported to be non-phytotoxic to plants at recommended application rates. From my reading of the accompanying information sheets, it appears to perform similar functions to the pool chlorine NaOCl that I have referred to throughout this article, although is considerably more expensive. According to the article I read, the nursery trade has been using this product for many years to treat benches, pots, growing media, foot baths and treating seedlings etc. Controlling these rapidly multiplying plant diseases is challenging. For example, bacterium cells can divide and multiply themselves every 30 minutes, which means that in 24 hours a single cell could produce 281,474,956,710,656 offspring! Water is the main carrier of diseases that affect orchids including *Erwinia, Fusarium, Phytophthora, Pseudomonas* and *Pythium*.
Insect pests

Fortunately, Paphiopedilum and its relatives seem less attractive to the wide range of insect pests that encounter than most other orchids. However, there are a few that do fancy our plants and wreak havoc at the most inopportune time.

Caterpillars and green loopers are the larvae of moths and butterflies. We all experience the hairy black caterpillars that abound in early spring. These unwanted visitors to your glasshouse are quite selective – it is likely that they will fancy the flower bud of your best and most showy orchid rather than something that is more drab or less appealing. The simplest control measure is to prevent butterflies and moths from entering your orchid growing area to lay eggs by covering the opening with flywire. However, this is not always feasible and direct action, ie removing and squashing them is possible, there is a very effective organic product Dipel that contains *Bacillus thuringiensis*, abbreviated to Bt. This product is very effective, highly selective against most species of caterpillars and has little or no adverse effect on other beneficial insect or aquatic animals. This biological control is in fact a bacterial stomach poison for all caterpillars, mixed with water and sprayed onto foliage. It must be ingested by the actively feeding caterpillar, which dies 3-5 days later. It is totally safe to beneficial insects, bees and mammals. Bt is broken down by sunlight within a few days; so repeated applications may be necessary.

Slugs and snails similarly can damage your flower buds and new growths which are soft and therefore more appealing. There are many commercial baits in the marketplace, however most are highly toxic to domestic animals, so ensure that your dogs and cats are not able to get to the baits. They also need to be placed so that they do not get wet as they are generally made of bran which will swell up and make them unusable. Crystalline Metaldehyde can be distributed around your glasshouse/shadehouse to deal with garlic snails, but this is a seriously toxic poison and considerable care is required in its use.

The presence of ants in orchid pots is often a sign of uneven watering, although I recently repotted an *Oncidium ensatum* in a large pot that contained a big ant nest even though the media was very wet. The ants provide transportation for hard and soft scale, and in return, receive a benefit by ‘milking’ the sweet honeydew exudate from the scale. So, if you see evidence of ant activity in your glasshouse, you need to do something about it. There are some excellent products in the market, both organic and inorganic, and many home remedies that can be found on the internet to deal with ants. Other members have found Amdro to be highly effective in ant eradication, while other products have not proven very effective.

Sap-sucking insects including hard and soft scale and mealy bug are the curse of many orchid enthusiasts, particularly those of us who do not have adequate space between our plants to allow really good air movement. I have found that eco pest oil is quite effective against these insects but requires frequent re-application. This product works by breaking down the insect’s waxy protective coating, but is not of itself a poison. If necessary for particularly heavy or persistent infestation, an insecticide such as Confidor ® can be added. For isolated insects, methylated spirits and water can be applied using a small paintbrush or cotton bud and used to remove the insects. Biological controls of mealy bug such as predatory ladybirds (Cryptolamus) are effective, but the predators perish unless there is a consistent source of mealy bug for them to feed on.