

## The benefits of hygienic practice in keeping your collection free of plant diseases.

At our last general meeting, one of our newer members, Tara Peeters told me that local orchid societies seemed not to pay much attention to plant hygiene and good practice in the cultivation of orchids (and for that matter, other ornamental plants) when developing topics for discussion with their members. She felt that this was a significant omission as many orchids are lost through fungal or bacterial infection transmitted from one plant to another via cutting instruments, or from recycling pots that have not been adequately sterilised. Another option is to single use disposable razor or scalpel blades.

As I operate a registered quarantine glasshouse, I am conscious about the potential to spread disease if good hygienic practice is not followed. In the closed confines of a quarantine glasshouse where I cannot apply fungicide or bactericide without approval, good hygiene is essential.

As a logical way to tackle what is a broad range of issues, I will start with disease control. The most common diseases affecting orchids are fungal pathogens, bacterial pathogens and viral pathogens.

### Fungal pathogens

Common fungal pathogens affecting our orchids are the "rots". One of these is *Pythium* black rot which generally affects *Cattleya* species and hybrids. Most of us will have experienced 'damping off' of our small seedlings out of flask. This is caused by several soil-borne fungi including *Pythium*, *Phytophthora*, *Rhizoctonia* and *Fusarium*, which infect seedlings and cause them to 'damp off' or collapse and decay. *Botrytis* infects flowers during the more humid months resulting in watery spots in the flowers.

These pathogens can be transmitted on instruments, from handling infected plants and then handling uninfected plants, from infected media and from reused unsterilised pots, and in some cases by water splash from one pot to another. There are many products in the commercial marketplace to deal with plants infected by these pathogens, and I will examine some of these in a further part of this article.

However, for the purposes of this discussion, sterilising cutting and other instruments can be simply effected by immersion in sodium hypochlorite (NaOCl). This is probably the cheapest and most readily accessible sterilant for most of us and can be purchased as liquid pool chlorine. The active ingredient is the same as bleach which normally contains about 6% of NaOCl by volume/weight. Pool chlorine is a more concentrated form generally around 12-14% NaOCl by volume/weight, that is, approximately twice as concentrated as household bleach.

The research I am familiar with indicates that an 0.5% solution is generally strong enough to kill *Fusarium*, *Pythium* and *Botrytis* fungal pathogens present in sap provided a long period of immersion is provided (say 20 minutes), although for *Phytophthora*, this needs to be at higher concentration of at least 2%. While it is probably overkill, given the inexpensive nature of pool chlorine, I believe that it is also worth sterilising media before using. This can be achieved by soaking in pool chlorine NaOCl at a concentration of 100 ml/10 litres of water for 24 hours. After draining off this solution, the media should be rinsed with clean water and kept isolated until used. Another benefit from this treatment is the effective control of thread fungus, the destruction of snail, slug and other unwanted insect pest eggs, and ensuring that the pinebark or other media is saturated before use. I also soak any wooden or cork slabs to be used for mounting plants in quarantine in NaOCl solution as it stops the growth of bracket fungus and algae, and perhaps kills any borer eggs that may be present.

A traditional method of sterilising instruments has been flaming. This can be achieved through flaming with a cigarette lighter or butane torch but needs to be done until a colour change to red heat is observed. However, this is generally damaging over the long term to your instruments, although is adequate if time is of the essence rather than taking care of the secateurs.

Trisodium phosphate ( $\text{Na}_3\text{PO}_4$ ) is another traditional disinfectant that has fallen out of use, although is still used as an industrial cleaner and can be used for sterilising cutting instruments proving it is used at 10% concentration for a minimum of 5 minutes. However, long term use of this product damages even stainless steel blades. Other products include sodium hydroxide and hydrogen peroxide, the latter is recommended at 30% solution. I use a commercial sterilant, Virkon S at 1%, but it is a relatively expensive product and I am not sure that it is warranted.

### Bacterial Pathogens

There are many bacterial pathogens, however one of the most persistent and damaging to our orchids is *Erwinea*. This disease can be particularly hard to control and rapidly lead to the death of even large plants. *Paphiopedilum* orchids seem to be very susceptible to this pathogen. While bacterial pathogens are considerably

more difficult to control than fungal pathogens, NaOCl at 0.4% concentration (40 ml in 10 litres of water) has been found to be effective as a drench, although a much stronger solution is required for sterilising cutting and other instruments.

### Viral Pathogens



Tobacco mosaic virus

Source: <http://staugorchidsociety.org/culturepests-viruses.htm>

Many of you will have heard about some of the viruses that infect orchids, specifically Mosaic Virus (TMV) and Odontoglossum Ringspot Virus (ORSV) that are generally transmitted from plant to plant by physical means such as secateurs or other cutting instruments (virus pathogens are able to survive for more than a week in dried plant sap), using previously contaminated pots etc. which leads to sap exchange and a transfer of infection or poor general hygiene which allow plant-to-plant sap exchange.



Odontoglossum ringspot virus

More recently, Orchid Fleck Virus has been found in local collections. This virus is much more difficult to detect as the popular and inexpensive virus test kits cannot test for this virus. Furthermore, its main transfer vector is sap sucking insects making it considerably more problematic to control.



Chlorotic flecks and different patterns of chlorotic spots and ringspots caused by Orchid fleck virus (OFV) on the leaves of *Miltonia* sp, *Cattleya* sp, *Brassia* sp, *Odontoglossum* sp and *Bulbophyllum* sp.

Source: [http://www.scielo.br/scielo.php?pid=s0103-90162010000300014&script=sci\\_arttext](http://www.scielo.br/scielo.php?pid=s0103-90162010000300014&script=sci_arttext)

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. It is recommended that the plant be properly disposed of; in practice, 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 (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).

However, as noted earlier, the prime means of virus cross infection is contaminated cutting instruments and/or contaminated pots or containers. As virus symptoms may not always be visible, for example, the colour break in *Cattleya*, *Odontoglossum*, *Cymbidium*, *Vanilla*, *Epidendrum*, *Encyclia*, *Oncidium*, *Phalaenopsis* and many other orchid genera flowers which is the physical evidence of ORSV may not be evident in the leaves and is therefore only visible during flowering.



Cattleya flower showing colour break

Source: <http://staugorchidsociety.org/culturepests-viruses.htm>

Similarly, the symptoms of viruses such as TMV often present when the plant is under severe stress rather than when it is in healthy growth. For these reasons, I believe that it is important to practice good hygiene at all times. Sodium hypochlorite at 10% solution for a minimum of 5 minutes was found to be effective in inactivating TMV and ORSV. 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. Evidence suggests that trisodium phosphate is 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 issue with all of these methods is the time taken to sterilise cutting instruments when we often 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.

The rules for minimising the opportunity for disease transmission are in essence quite simple, and probably seem

obvious to all of us, however I suspect that many of us are less than conscientious in our day-to-day practice. For example, do we sterilise our secateurs after we remove a flower spike from one orchid before doing the same to another, or before we divide another orchid. I suspect that from time-to-time, expediency is more important than good practice.

Last month, I provided some ideas about how better hygienic practices can help keep your orchid collection free of some of the more preventable diseases. The first part of this article was focused on best practice for sterilisation of cutting instruments and containers etc. to minimise the spread of disease by sap transfer. In the second part of the article, I will concentrate on plant management or husbandry. In this regard, I will also refer to insect pests. As mentioned earlier, they can spread viral and other diseases, or foster the spread of fungal pathogens such as sooty mould which will grow on the sugary exudates from sap-sucking insects.

### Glasshouse/Shadehouse Management

In this context, I must confess to “do as I say, not as I do”. By and large, as enthusiastic collectors, we acquire more and more orchids, and constantly add plants to our collections without taking account of the space we have available, or ‘quarantining’ them before adding them to our collection. An old rule of thumb suggests that the space between your orchid plants should be equivalent to the size of the pot, ie, providing adequate corridors for good air movement and for you as the grower to be able to clearly see each pot and orchid plant when you are watering/fertilising. This would be the “gold standard” and as we observe when we visit growers who are able to keep the size of the collection under control (or easily increase their glasshouse/shadehouse size), the plants are more healthy and have less problems with insect pests and fungal/bacterial pathogens. But, being realistic, none of us has unlimited resources and room, so some form of compromise is necessary.

The disease and pest problems that can be attributed to overcrowding are many, but for simplicity, I will categorise them as sap-sucking pests, and common fungal pathogens. Orchid fleck and other virus can be transmitted by plant to plant contact, although orchid fleck virus is also directly transmitted by insects.

### Reducing the Adverse Impact of Plant Pests

The problematic plant pests in WA are principally sap-suckers including hard and soft scale and mealy bug; mites; slugs and snails, caterpillars, and flying insects including aphids, thrips and white fly. Simply put, a clean and hygienic environment, free of dead plant material with adequate space between plants to allow plenty of air movement, appropriate light, and maintenance of required humidity can help to keep these pests at bay. However, as previously suggested, we do not all live in a perfect world and consequently need to maintain some form of regime to minimise the adverse effect of these pests.

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.

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.



Boisduval (Cotton) scale (*Diaspis boisduvali*) on orchid pseudobulb

Soft brown scale (*Coccus hesperidum*) on orchid leaf

From the NOVEMBER 2001 issue of Orchids -- The Bulletin of the American Orchid Society.  
Source: <https://www.aos.org/Default.aspx?id=137>





Mealy Bug *Pseudococcus longispinus* on orchids



Source: <http://www.rv-orchidworks.com/orchidtalk/orchid-ailments-compost-pile/16525-mealy-bugs-my-orchids-help.html> and <https://www.aos.org/Default.aspx?id=511>



Two-spotted mite (also known as red spider mite) and false spider mite are very damaging pests on orchids, and once established, can be very difficult to eradicate. As the common name suggests, they are not actually insects, but are closely related to arachnids (spiders). They are very small and best observed with a magnifying glass or by holding a piece of white paper under an infected the leaf and shaking some of the animals onto the leaf. They can then be seen with the naked eye moving around.

Magnified image of Two-spotted mite *Tetranychus urticae* Source: [https://www.ngia.com.au/Folder?Action=View%20File&Folder\\_id=135&File=Two%20spotted%20mite%20fact%20sheet%20FINAL%20V4.pdf](https://www.ngia.com.au/Folder?Action=View%20File&Folder_id=135&File=Two%20spotted%20mite%20fact%20sheet%20FINAL%20V4.pdf)

The presence of this pest is indicated by a silvery appearance to the underside of orchid leaves, generally seen firstly on *Dendrobium* and some other genera. This appearance is the result of the insect infesting the underside of the leaves and leaving a silvery deposit. This pest is difficult to eradicate as there are several different stages in their life cycle (wetable sulphur included in Mancozeb Plus ® will address some stages, but not all). As the population rises rapidly once egg-laying commences, frequent retreatment is necessary. Ordinary pesticides are not effective against this pest – specialist miticides are required, however these are often chemicals dangerous to us so care is required. If you have a major problem in a large collection of orchids, the following miticides are effective; Stealth®, Acramite®, Floramite ® & Vertimec®. Due to the short- life-cycle of this pest, they can quite rapidly develop resistance to particular chemicals (eg Kelthane®), so it is better to carefully manage your environment to make it less conducive to their occupation. Doing so requires good air movement, general cleanliness including removal of dead and damaged plant material, and maintenance of high humidity (this pest prefers low humidity/dry conditions). Another control option is predatory mites and insects although this is not really efficient in other than large collections as you need to maintain a small population of the pest to feed the predators.

Another group of pests are slugs and snails. Once again, the population is able to build up over time when hygienic practice fails and dead plant material is allowed to accrue in the shadehouse or glasshouse. These pests are very happy to live in the bottom of pots, or amongst companion plants growing underneath benches. They can be prevented from living in the bottom of orchid pots by putting a layer of coarse river gravel/ small rocks in the bottom of the pot, or a layer of shade cloth or flywire, however this can result in pots staying too wet if this layer becomes blocked. It may be that a layer of small styrene foam balls like those in beanbags will provide the same protection although I have not experimented with this. There are many commercial baits and products for dealing with these molluscs but in the moist environment in which we grow orchids, they often break down very quickly as they mostly include some kind of attractant in addition to the poison (generally metaldehyde) which swells when wet. These baits are also very poisonous to pets so care must be taken when using them.



Some other insect pests that are present from time-to-time are aphids and thrips. The former can be controlled by aphicides of which several containing Carbamate are readily available. There is potential for flower damage from liquid pesticides and wherever possible, for this reason wettable powder is preferred. Aphids are one of the known vectors transmitting orchid fleck virus, so it is important to deal promptly with any infestation that occurs. Small numbers can be washed off with water spray, remembering that eggs will be present and treatment will need to continue to break the life-cycle of this pest. In other parts of the world, it is a major pest in commercial orchid nurseries, particularly those in more tropical climates.

Source: [http://www.extento.hawaii.edu/kbase/view/files/pictures/m\\_lutem1.jpg](http://www.extento.hawaii.edu/kbase/view/files/pictures/m_lutem1.jpg)

#### Caterpillars and similar insects

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.



Similarly, thrips while not a frequent orchid pest in WA can infest plants if the conditions are favourable and are difficult to eradicate. The visible evidence of thrips is similar to that seen when mites are present, that is a silverying of the leaf surfaces. Unfortunately, thrips readily develop resistance to pesticides and only very strong insecticides such as Rogor or systemic products, are effective. If you need to use these products, regular rotation of the active ingredient is necessary to minimise resistance development.

Photo source: <http://www.orchideenforum.de/thripse.htm>

Fortunately, there are some biological controls becoming available that utilise fungal insect pathogens (cf products used for caterpillars) and biological control insects such as predatory mites and these options should be explored if the problem persists.

In summary, the best way to minimise the impact of these pests is to maintain a clean and healthy environment. This will mean that we need to:

- \* ensure that there is plenty of fresh air and air movement in our glasshouse/shadehouse;
- \* remove any diseased or damaged leaves, and dead plant material;
- \* maintain humidity and provide our orchids with water and nutrient when needed;
- \* provide adequate light (not too much or too little);
- \* promptly address any pest infestation; and
- \* if possible, avoid overcrowding our orchids so that there is space between our plants to permit air movement.

#### Biological controls

Considerable work has been done in Australia and elsewhere on the efficacy of biological insect control using predatory insects given the rising level of interest in organic foods where to maintain certification, inorganic and/or chemical controls invalidate certification. An Australian company, Biological Services at <http://www.biologicalservices.com.au/products.html> list a range of predatory controls that that can be used. These include ladybirds, predatory mites, wasps and other beneficial insects. The challenge however in using biological control is maintaining a population of the insect pest so that the predator does not die out. This can be virtually impossible in a small glasshouse/shadehouse, or a domestic garden. These approaches are much more applicable to broad scale horticulture/agriculture as part of a balanced program of insect and pathogen control.

#### Fungal and Bacterial Pathogen infections

Earlier in this article, I referred to some of these pathogens in the context of hygienic practice, specifically in maintaining cleanliness of cutting instruments and pots. However, even if we follow good practice, from time-to-time, we will need to deal with infections that take hold in our orchid collections. It is also worth remembering that even in a perfect world, plant pests and pathogens exist, and if we make sure that our orchids are healthy and strongly growing, they will be better able to resist any attack. The most likely time of year for these infections to occur are the season changes, that is early spring and autumn where the humidity is high, growing conditions are changing and these pathogens are active in the general environment outside our glasshouse or shadehouse.

#### Black Rots

Black rot in orchids can be caused by many pathogens some fungal or close relatives and others by bacteria such as *Erwinia*. All lead to significant damage, and often death of the plants infected, so need to be promptly addressed infections are present. The most common are the water moulds, *Phytophthora* and *Pythium* that are

often loosely referred to as fungal pathogens but are in fact protists or Oomycetes (one-celled organisms, classified in the kingdom Protista, that is either free-living or aggregated into simple colonies and that have diverse reproductive and nutritional modes, including the protozoans, eukaryotic algae, and slime moulds). 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.

Often the infection is first observed as 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. For example, in *Vandas* the infection may start on new leaves as a soft, dark brown to black rot. Over time if left untreated, the infection progresses down the stem which becomes dark brown in appearance. In *Cattleyas* the first signs of infection will be seen in the new growths turning them black and soft. Unless treated, the infection can spread along the rhizome to the next growth causing the same symptoms. Prompt action is required to halt the spread of infection otherwise it will continue to spread rapidly throughout the orchid leading to its death. While leaves may initially show signs of infection on only one side, the infections spreads rapidly and the entire leaf soon turns black.



Photo source: <http://www.plantmanagementnetwork.org/pub/php/diagnosticguide/2010/orchid/>

What distinguishes these black rots from fungal pathogens such as *Colletotrichum closeporiodes* (commonly referred to as *Anthraxnose* or *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 has a very offensive smell.

*Pythium* is an infection that 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.

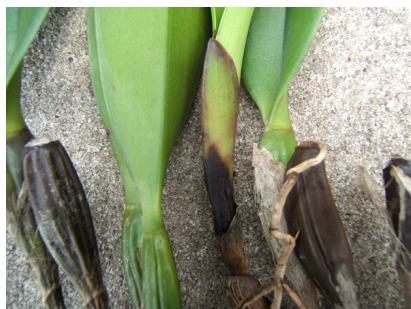


Photo source: <http://www.hark-orchideen.de/Pflanzenschutz/Pythium/bilder.php?lang=en&navID=99>

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.

### Oomycetes Black Rot control

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 algicide, 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-immerses in a freshly made solution for a further 10 minutes.

Black rot in Cattleya orchid due to *Phytophthora cactorum* Photo source:  
<http://www.plantmanagementnetwork.org/pub/php/diagnosticguide/2010/orchid/image/orchid1.jpg>

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 phosacid, 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* (Ridomill 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.

Unfortunately, none of these products control diseases caused by other fungal pathogens. Thus, alternative fungicides are required to control leaf-spotting diseases or root rots caused by fungal pathogens such as *Fusarium* or *Rhizoctonia*, although Phosphorous-acid based fungicides such as Fosject®, Agrifos® or Phosacid®, provide some measure of both protective and curative action against *Phytophthora*, and therefore, Yates Anti-Rot might be the best low-cost product to purchase, particularly if your orchid collection is only small. There is some evidence that these fungicides may also stimulate the natural resistance of the plant. They have very low toxicity and can therefore be used as a prophylactic treatment. As part of this preventative approach, spraying of your glasshouse/shadehouse roof and walls, floor and benching with Alginox® on a regular basis will help limit the growth of spores and minimise the opportunity for this pathogen to become established, as will ensuring that orchid foliage does not remain wet for extended periods of time. I will cover the common and less common fungal pathogens later in this article.

### Common Bacterial pathogens

St Augustine Orchid Society in the US has an excellent page on its website devoted to orchid pests and diseases with photos of many of the more commonly encountered fungal and related pathogens – see <http://staugorchidsociety.org/culturepests-diseases.htm>. These bacterial pathogens are more common than generally thought, and can be difficult to combat once they become established.

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.



Bacterial brown spot is a common and severe problem with *Phalaenopsis* orchids although many other orchid genera can be affected.

*Pseudomonas* spots on *Phalaenopsis* leaves.

Source: <http://staugorchidsociety.org/culturepests-diseases-pseudomonas.htm> and



<http://staugorchidsociety.org/PDF/BacterialBrownSpotbySueBottom.pdf>

*Pseudomonas* treatment involves killing the bacterium, and preventing reinfection by rectifying the environmental conditions that allowed it to gain a foothold in the first place. Localised infection may be treated with Hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>), although it is prudent where possible to remove the infected leaf tissue below the infection. I suspect that treatment with NaOCl would also be effective as a sterilant in these circumstances. It is very important to preventative treat 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, and these can be applied to plants, benching, wall/floor/roof surfaces. The environmental control required is to increase air movement so that no plant leaves are wet for extended periods of time during the daylight hours, or overnight.

*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 it can be eradicated. 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 if 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. However, treatment needs to be applied to infected plants, which should be quarantined to minimise the spread of infection. As there are few treatments that are effective, it is prudent to excise all infected parts of the plant(s) and treat the remainder



*Erwinea* sp on  
*Paphiopedilum* plants. Source:

<http://staugorchidsociety.org/culturepests-diseases-erwinia.htm>

My research revealed that substantial research has been carried out in the US dealing with *Erwinia* soft blight infections in *Paphiopedilums*, and in commercial horticulture, for *Oncidium* and *Phalaenopsis*. 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 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.

#### *Erwinia cypripedii*.

Another soft rot bacterium, this disease infects 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 start again. Following treatment, the foliage should be kept dry with watering applied carefully to avoid any splash onto the leaves. Treatment with a systemic fungicide (Fongarid™) every three months can be an effective deterrent, keeping in mind the need to rotate fungicide to minimise development of resistance.

#### Bacterial soft rot (*Erwinia carotovora*).

From my research It appears that this disease is incurable. *Cattleya* is the genus that is mostly affected by this disease but other genera can also be affected. Although a rare disease in most collections it is so destructive that removal of the plant and destroying it is the only effective solution. The disease starts as a water-soaked dark green spot appearing on the upper end of the leaf. It will break open at a slight touch, the inner tissue of the leaf is destroyed and the leaf appears flaccid and wrinkled. If the leaf breaks then the rest of the plant, bench and



whole surrounding area will be contaminated by the bacterium. Clean up of the area with a strong solution of NaOCl is recommended after removing the plant.

Bacterial leaf rot (*Erwinia chrysanthemi*).

This is a relatively new disease, can be water-soaked, brownish or water-soaked with a yellowish appearance. In some genera it is translucent on the leaves, in other words you can almost see through the leaf and gradually the colour becomes darker to black and sunken. As a preventative measure it is best to spray the surrounding areas and plants with fungicide before and during wet weather. To control the disease on the plant itself remove or cut out the infected area from the leaf and treat with fungicide

As an example of just how serious this bacterial infection can be, Fire Blight (*Erwinia amylovora*) is a very serious problem for the Apple and Pear orchard industry in the US and elsewhere, but fortunately has not been able to establish a foothold in Australia, although was identified and believed to have been eradicated in Melbourne's Royal Botanic Gardens in 1997. This species primarily affects some 75 members of the *Rosaceae* family that includes apples and pears, but fortunately, does not appear to infect orchids.

### Fungal Pathogens

Fungal pathogens are very diverse in nature and can equally affect leaves, roots and flowers. As the most effective treatments can be specific to the pathogen, it is important to determine what the problem pathogen is before considering how to treat it. That is why it is essential to figure out what type of fungal infection you are dealing with before determining the proper way to treat it. *Cercospora sp*, *Septoria sp*, *Guignardia sp* and *Phyllosticta sp*, often referred to 'leaf spots' are rust-like fungal pathogens that can affect orchids, and given their nature can be very difficult to eradicate. The first step is to remove infected leaves using sterilised cutting instruments, and disposing of the infected leaves to prevent the infection spreading from spores released by the fruiting bodies.

*Phyllosticta capitalensis* on Vanda

Source: <https://www.aos.org/Default.aspx?id=135>



*Cercospora*, *Septoria*, *Guignardia* and *Phyllosticta* are 4 types of fungal infections that are commonly referred to as leaf spots. However, as you will see from the following, it can be difficult to identify precisely which of these pathogens are infecting your orchid as the presentation can vary and can also resemble other bacterial and fungal pathogens. Accurate identification requires more specialised skills and techniques than the average orchid hobbyist would have at their disposal, however, there are common remedies for this group that can be used.

Firstly, as a simple means of reducing spread of the disease, the leaves which become infected should be removed using sterilized equipment and properly disposed. Following removal of damaged leaves and application of treatment, the infected orchid plant leaves should be kept dry and water should not be allowed to accumulate and remain on the leaves. To minimise the opportunity for these unsightly diseases to infect all the plants in your collection, particularly if some plants have become infected it is prudent to use good quality protectant (egg Mancozeb®, Coppox WG®, Amgrow Copper Oxychloride®, Bordeaux, Kocide Blue) and systemic fungicide (eg Fongarid®, alternately. Sometimes, these fungal diseases become a recurring problem which is why it's best to use a fungicide spray on a monthly basis in order to reduce the risk of recurring fungal infections.

A *Cercospora* infection at first appears as a yellow spot on the underside of the leaf. Soon after infection occurs, a yellow-green area may be noted on the top surface of the leaf. As the spots enlarge in irregular patterns, they become slightly sunken and necrotic and turn purplish-brown to purplish-black in colour. These spots continue to



*Cercospora* on orchid leaf

enlarge in either circular or irregular patterns and may eventually cover the entire leaf. The active infection margins continue to be yellowish in colour, and eventually, the most heavily infected leaves will fall off the plant especially those where the infection started near the base of the leaf.



*Cercospora* on *Oncidium*

Photo source: <http://staugorchidsociety.org/culturepests-diseases.htm>



*Cercospora* on *Cattleya* leaf

Photo source: [http://farm8.staticflickr.com/7025/6509651297\\_5b4644751a.jpg](http://farm8.staticflickr.com/7025/6509651297_5b4644751a.jpg)

“*Thai Orchid Disease*”

*Guignardia* and *Phyllosticta* are collectively known by the common name Thai Orchid Disease. The first plants discovered with this infection were strap-leaf *Vanda* hybrids from Thailand, although in common with fungal pathogens generally, there are many different species and some of these will infect other exotic and fruiting plants. This disease severely weakens the plant, and ultimately leads to its death. *Phyllosticta capitatus* is the most common species infecting orchids, however as Martin Motes writes, “in fairness to the Thais, it is in fact cosmopolitan. Amateur growers have exceptional difficulty controlling this disease largely because of a lack of understanding of its life cycle. An understanding of this fungus makes it no more difficult to control than any other of the leaf spotting fungi such as *Cercospora*.”

Although Martin Motes says that this disease is no worse than many other fungal pathogens, in an article published by the Rockhampton Orchid Society, the author says that “it is without doubt one of the worst pathogens of the group of plants we generally refer to as *Vandas*”. This is because this genus is relatively disease resistant, and often less closely observed than other species. Unless this infection is controlled, plants infected become weak and are then easy targets for other opportunistic pathogens.

The initial symptoms may appear on both upper and lower leaf surfaces as tiny, dark-purple, elongated streaks, oriented along the leaf parallel to the veins. As this streaking spreads, the infection creates elongated, diamond-shaped lesions that can be up to 3 cm in length. Over time, the lesions join together to form irregular areas that may cover a significant proportion of the leaf. The lesion may also be full leaf thickness. Over time, the centres of the lesions turn tan to dark brown, sometimes with a silvery overlay, while some lesions will remain dark purple in colour. The lesions adversely impact the plant’s photosynthesis process by reducing the leaf surface area available for this purpose. They are the site of spore production of the fungus which reproduces by both sexual and asexual spores. Initially, asexual spores (conidia) are formed in the fruiting bodies (pycnidia) that form in the lesions. The early mycologists who studied this pathogen named it as *Phyllosticta*.



*Phyllosticta* on *Dendrobium* leaves

Photo source:

<http://staugorchidsociety.org/culturepests-diseases-leafspots.htm>

*Guignardia*  
infection in orchid leaf

The conidia are released when there is water on the leaf surface, and require water to germinate therefore; it is simpler to control if plant wetting from rain can be restricted by an impermeable roof. While this fungus attacks both new and old leaves, the infection can take several weeks or even months to be visible, this generally the lesions are most commonly present on mature leaves that can remain attached to the plant for several months and continue to produce spores spreading the infection. Accordingly, where practicable, diseased leaves should be removed and properly disposed. Shortly after the pycnidia appear, the pathogen produces different fruiting bodies (peritheca) that produce packets of sexual spores. The mycologists who studied this part of the life-cycle of the fungus knew all about sex and named the fungus as *Guignardia*. It is now recognised that *Phyllosticta* and *Guignardia* are in fact the same organism.

*Phyllosticta* infects a wide range of orchid genera including the *Cattleya* alliance, *Dendrobium* and the *Oncidium* alliance in addition to the *Vanda* alliance. Therefore, some substantial steps must be taken to control this disease

if it appears. While not all of us grow Vandas, the fact that this pathogen also infects other genera is of concern.

*Phyllosticta* seems to just suddenly present on otherwise healthy plants. Most often, this appears to occur following significant seasonal temperature change in late autumn/ early winter/early spring that induces 'cold stress' in these tropical species. As advised earlier, the lesions are in fact the fruiting bodies of the fungus that has been present for some time. This presentation is analogous to the appearance of "fairy rings" of toadstools after a heavy rain. Like the mystery that surrounded the sudden appearance of toadstools, many orchid growers mistakenly believe that *Phyllosticta* is a systemic problem like a virus. It is not – it is a fungal disease of an individual leaf that spreads to other leaves via spore, often from the older leaves to the newer leaves as they form. While this disease is not inevitably fatal to the plant, it is extremely persistent and difficult to control requiring persistence and commitment from the grower to the control regime adopted.

The first step, as reinforced throughout this article is general cleanliness and effective plant hygiene. Keeping the shadehouse or hothouse pathogen-free is the starting point. Therefore newly purchased orchid plants should be carefully inspected to make sure they are disease free. Dead leaves, used potting mix and other spilt organic material should be promptly removed from the floor and benches and properly disposed of into the wheelie bin as they can be an ongoing source of infection. Perithecia may develop in fallen leaves and will continue to produce infective spores for as long as they remain.

Control of infection in plants is the next step. If the orchid is not one that is valuable, or has a special place in your collection, consign it to the wheelie bin. Otherwise, an effective fungicide program is required. Regular application of Mancozeb® will kill the fungal spores but will not deal with the pathogen present in the leaf tissue. This requires a systemic fungicide. A readily available systemic fungicide that is reasonably effective and has very low mammalian toxicity is Triforine (rose spray). A more effective systemic is thiophanate-methyl, but this is not generally available from the usual supermarket outlets. Banrot 400WP® Broad Spectrum Fungicide for Ornamentals has thiophanate-methyl as an active ingredient. A combination product, Zyban WP that included Mancozeb® has been deregistered, so it would be wise to mix Banrot 400WP® with Mancozeb® to have a contact fungicide to kill the spores and so stop new infections and a systemic fungicide to kill the fungus. It should be applied at the recommended rate for ornamentals. Ridomil Gold® may be equally effective for this purpose. This regime will also address *Cercospora* and *Fusarium*.

Remember, once the plant is infected, disease-free status must be achieved and then maintained so that all newly emerging leaves remain disease free. This may take some years before you can confidently say that you have cured your plant(s). This reinforces the benefit of taking care initially to avoid introducing disease into your collection through adding diseased plants purchased at an orchid shows, or by contact with diseased plants on display (where they act as a source of inoculum for other plants).

As I discovered some years ago, *Phyllosticta sp* can be almost impossible to control once it takes hold in a collection. We had more than 300 Vanda species and hybrids in quarantine, two of which exhibited an infection that resembled rust at a three monthly inspection. Naturally, this caused considerable concern with AQIS. Given the nature of our facility, we were unable to effectively isolate the vandaceous species and hybrids from the others in quarantine, and with AQIS assistance, we then commenced a program of approved control to endeavour to eradicate the infection. Despite nearly 18 months of effort, with controlled treatment removing all infected leaves, cover spraying plants and glasshouse floor, walls and roof with firstly Mancozeb® as a contact kill spray, and then strong NaOCl solution as a disinfectant on a rotating weekly basis for 8 weeks (4 weeks each) before observing the plants for 3 months for any signs of re-infection, we were unable to control this pathogen. We were given approval to use Rovral ® as a systemic fungicide in place of the Mancozeb®, but this failed to halt re-infection and eventually all vandaceous species and hybrids were destroyed. However, this particular *Phyllosticta sp* was very specific to vandaceous species and hybrids and did not infect any other species that we had in quarantine at the time. The Plant Scientist at AQIS arranged DNA sequencing should this particular strain re-appear in future.

*Septoria* is another fungal spot disease. Tiny spots on leaves may start out on both upper and lower leaf surfaces as sunken, yellow lesions that enlarge into dark brown to black circular or irregular lesions. These lesions can merge to form large, irregular patches on the leaf, and as with other fungal pathogens, severely infected leaves fall prematurely. Treatment is similar to the fungal pathogens already covered in that damaged leaves should be removed with a sterile instrument, watering reduced and plants treated with a combined systemic and contact fungicide such as Ridomil Gold WP® or Banrot 400WP® with Mancozeb® in accordance with instructions for ornamental plants (both rate and frequency). As for fungal pathogens generally, prevention is the best approach

and sound sanitary practice combined with good air movement and water management will help. I also apply prophylactic fungicide cover spray at the change of seasons (summer→autumn, winter→spring) using products such as Ridomil Gold WP®, Mancozeb Plus®, CoppoxWP®, Bordeaux or similar products. These products should be used alternatively to minimise opportunities for pathogen resistance, and taking care to carefully observe any damage to plants (Dendrobiums can be susceptible to copper).

*Botrytis*, commonly known as petal blight is another fungal infection which plagues orchids. To treat your orchid plant, it is important to remove the flowers which become infected. Spraying the contaminated plant as well as the surrounding ones with a good protectant fungicide also helps to reduce this infection. Since this is a very common fungus, there is no way to completely eliminate it, but proper care and sanitation, lower humidity, warm temperatures and improved air flow in the growing area can substantially reduce the damage caused by this fungus. The spots may enlarge and cover the entire flower, and when ideal conditions exist, a grey fungal growth may also appear on severely infected flowers that will collapse as the infection takes hold. This pathogen is always present and cannot be eradicated, only controlled. Infected flowers must be removed promptly as the infection will spread rapidly and infect other ornamental flowers. This fungal pathogen is particularly damaging to Dendrobium flowers (Phalaenopsis type) that are flowering in late autumn/early winter when the increased humidity allows this pathogen to flourish.



*Botrytis cineria* on Phalaenopsis flower Photo source: <https://www.pinterest.com/kkorchid/orchid-pests-and-diseases/>

Botrytis spotting on *Laelia anceps*



*Rhizoctonia* is another common fungal infection which debilitates the roots and in due course, the leaves. This root rot generally presents when the medium breaks down, drainage is poor and/or plants are overwatered. It can also infect your orchid arise when its 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. As above, *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 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 Ridomil 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. 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.



Fungal root rot in *Cattleya*

Photo source: <http://staugorchidsociety.org/culturepests-diseases.htm>

The topical fungi such as *Anthracoze*, *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. *Anthracoze* is a fungal infection which usually affects the air borne parts of the plant, mostly the leaves



*Glomerella (Anthracnose) on Paphiopedilum*

Photo Source <http://www.parramattaorchidsociety.org/Major%20Fungal%20and%20Virus%20Diseases%20%20Orchids%20PDOS.pdf>



In order to treat your plant it is important that you apply a protectant and a 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 infested 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.

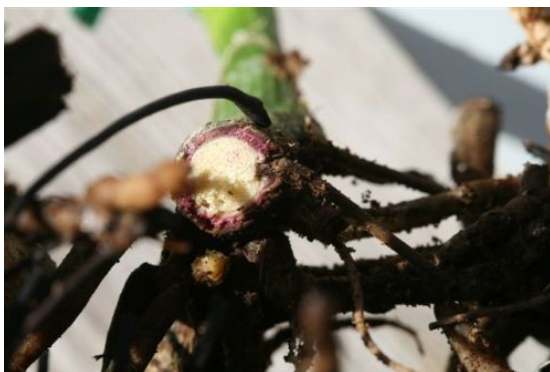
While these pathogens are more often unsightly rather than fatal to the plant, an *Anthracnose* infection in a *Paphiopedilum* can lead to the loss of the plant. My research indicates that Octave® is an effective fungicide to treat this unsightly and damaging pathogen. It is applied at 1 gm/litre of 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*

Photo source: <http://www.hark-orchideen.de/Pflanzenschutz/Colletotrichum/bilder.php?lang=en&navID=99>

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.

*Fusarium* wilt (*Fusarium oxysporum* and *Fusarium solani*) is an infection which enters through the roots or the pseudobulbs of the orchid. It is quite common in newly divided plants and the infection cuts off the flow of water through the veins of the plant, resulting in stunted, shrivelled or wilted leaves, with in some instances, chlorosis visible. This pathogen can be very damaging in all orchids, but it appears that *Phalaenopsis* are most susceptible, although it is also known in *Cattleya*, *Dendrobium*, *Oncidium* and *Vanda*. In advanced infections, a brown-black rot can extend into pseudobulbs, and may present a pink-purple discoloration at the leading edge of the infection. Once the organism becomes established the infected area quickly browns off and has a distinct yellow/green halo around it, and more often than not, the brown dead tissue has a concentric ring appearance.

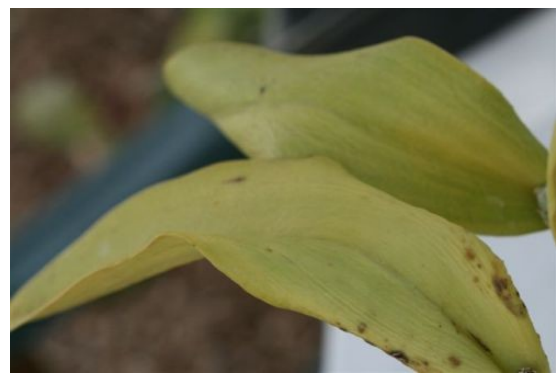


If the disease spreads through the plant to a greater extent the entire bulbs turn purplish, the infected parts should be removed from the plant. The plant should be repotted, keeping only the unaffected parts and removing all tissue. The repotted plant should be soaked in a fungicide and the entire growing area should be disinfected.

*Fusarium* wilt showing purple discoloration

Source: <http://staugorchidsociety.org/culturepests-diseases-fusarium.htm>

As always, cutting tools must be thoroughly sterilized every time they come in contact with an infected plant to avoid transferring the infection to healthy plants.



*Fusarium* wilt showing chlorosis and leaf wilting

Source: <http://staugorchidsociety.org/culturepests-diseases-fusarium.htm>

US publications refer to a new combined fungicide that has been found to be effective in dealing with this infection. The product contained fludioxinil® and cyprodinil®, but is not registered for Australia, although a product with similar formulation called Switch WG® from Sygenta is available, although is expensive at \$190 a kg. E.E. Muir & Sons at [www.eem.com.au](http://www.eem.com.au) list this product although I have not confirmed a price. The active ingredient, azoxystrobin® which is a systemic product is found in Azoxystrobin 500 WDG available from 4Farmers in WA in a 1kg pack .Other protective treatments include chlorothalonil® as the active ingredient of Chlorothalonil 720® from Cheminova and a similar product from Bayer Cropscience, however, as with other Group Y fungicides, pathogen resistance can be a problem and should be managed by fungicide rotation. Once again, these products are likely to be quite expensive. Banrot® 400WP also appears to be effective against this pathogen and is available from Garden City Plastics at \$275 + GST for a 900gm pack.

*Sclerotium* (Southern Blight/Collar Rot) is a common disease in *Phalaenopsis* orchids and rapidly leads to death of the plant. The principal symptoms are the rotting and collapse of roots, pseudobulbs and lower leaves, with the lower stems often turning creamy-yellow before becoming brown as the damaged tissue is invaded by other opportunistic fungal and bacterial pathogens. The affected tissue rapidly collapses and rots, while the advancing disease leads to the death of the basal parts of the orchid. The leaves wilt, turn yellow and die. Often small yellow or tan sclerotia resembling mustard seeds that form on the affected tissue (the resting form of the fungus) will be seen. The following photos show early stage, advanced stage and end stage of this disease in a *Phalaenopsis*.



Photo source: <http://staugorchidsociety.org/culturepests-diseases-sclerotium.htm>

diseases-sclerotium.htm

This fungal pathogen is more vigorous in conditions of high humidity and temperature, and management of these glasshouse environmental factors can be important in controlling this disease. However, most often the disease is well advanced by the time symptoms are observed and consequently, the plant(s) cannot be saved. It is critical at this time that facility hygiene is stepped up with disinfection of the benches, walls, floors etc with NaOCl or Benzalkonium chloride. Plants should be treated with a systemic fungicide such as Banrot®. Reducing temperature and humidity can assist in reducing the spread of this disease.

Pathogen	Preventative		Infection	
	Product	Treatment	Product	Treatment
Brown rot ( <i>Erwinea</i> )	NaOCL Fongarid	5ml/l as a drench Prophylactic spray as per manufacturer's advice for ornamentals	Ridomil Gold Kocide Blue Xtra NaOCl	Removal of infected leaves/plants 2gm/l 1.5gm /l
Bacterial Brown Spot ( <i>Pseudomonaas</i> )	Alginox, Kocide, Blue Extra, Yates Liquid Copper	15ml/4l as a drench Other products as per manufacturer's instruction for ornamental plants	Ridomil Gold NaOCl	Removal of infected leaves/plants 2gm/l
Crown & Root Rot ( <i>Rhizoctonia</i> )	Alginox, NaOCl  Kocide,Blue Extra, Yates Liquid Copper	Alginox 5ml/l drench for other plants. Other products as per manufacturer's rate for ornamental plants	Ridomil Gold WP	Removal of infected leaves/plants 2 gm/l
Black Rots ( <i>Phytophthora</i> and <i>Pythium</i> )	Alginox NaOCl Fongarid	15ml/4l as a drench 5ml/l as a drench Manufacturer's recommended rate for ornamentals	Ridomil Gold WP Fongarid Yates Anti Rot Alginox	2 gm/l Manufacturer's recommended rate for ornamentals 15ml/4l
Tropical Fungi ( <i>Anthracoese</i> , <i>Cercospora</i> , <i>Glomerella</i> and <i>Gloeosporium</i> )	Mancozeb, Zineb Coppox WG, Amgrow Copper Oxychloride, Bordeaux, Kocide Blue Extra, Fongarid	At manufacturer's rate for ornamentals. Rotation of chemicals is important to minimise developed resistance	Octave/Mancozeb	1gm/l Octave and 2gm/l Mancozeb sprayed onto both sides of leave until run-off.
<b>Insect Pest</b>				
Aphids	Predatory wasps <i>Aphidius colemani</i> , <i>Aphidius ervi</i> and <i>Aphelinus abdominalis</i>		Soapy water Eco-oil	Wash insects off Manufacturer's recommended rate for ornamentals
Caterpillars and loopers	Manual removal		Dipel	Manufacturer's recommended rate for ornamentals
Mealy Bug	Predatory ladybird <i>Cryptolamus</i>		Eco-oil Pest oil Confidor	Manufacturer's recommended rate for ornamentals
Slugs and snails	Slug and snail baits (Methocarb or Metaldehyde)	Distribute in area. Keep dry	Metaldehyde	Manufacturer's recommended rate for ornamentals
Soft and hard-bodied scale	Eco-oil		Eco-oil Pest oil Confidor	Manufacturer's recommended rate for ornamentals
Two-spotted mite (False spider mite)	Wettable sulphur  Predatory mite <i>Phytoseiulus persimilis</i>	As part of a prophylactic program	Stealth®, Acramite®, Floramite ® & Vertimec®	Manufacturer's recommended rate for ornamentals
Thrips	Killer mites <i>Hypoaspis aculeifer</i> <i>Orius tantillus</i>		Rogor	Manufacturer's recommended rate for ornamentals

### *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 a '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.

An article by F.A. Gutierrez-Miceli, T. Ayora-Talavera, M. Abud-Archila, M. Salvador-Figueroa, L. Adriano-Anaya, M.L. Arias Hernandez and L. Dendooven, 2008. *Acclimatization of Micropropagated Orchid Guarianthe skinnerii* Inoculated with *Trichoderma harzianum*. *Asian Journal of Plant Sciences*, 7: 327-330 reports a significant improvement in the survival and growth rates of *Guairiante skinnerii* seedlings ex flask after treatment with *Trichoderma harzianum*.

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*, *Erwinia* 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*.