A new view of tackling snowdrop diseases

After a disastrous outbreak of disease in a snowdrop collection, galanthophiles **David Way** and **Cor van Bakel** were spurred by the lack of information on the subject to conduct their own investigation. Their findings are essential reading for all who grow snowdrops

The first source of reference for information on bulb diseases was a 176-page book published in 1939 by the UK Ministry of Agriculture, entitled *Diseases of Bulbs*. The chapter on snowdrops refers to grey mould, *Botrytis galanthina*, as the *only* significant disease. In the past two decades this situation has greatly changed as additional diseases have become distributed and scientific knowledge has increased.

Many snowdrop enthusiasts are unclear about the symptoms of specific diseases, either because they have been fortunate enough not to have experienced them or because of the paucity of fully descriptive and illustrated information. In particular, existing texts are over-reliant on foliar symptoms, ignoring the bulb itself. In addition, because it is common for unexplained losses to occur, an attitude of acceptance seems to have developed on the basis that this is the norm. Although the current number of significant diseases is small their impact can, on occasion, be devastating.

Here we present recent experiences and information gained through an investigation which started in July 2013. It was triggered by the chance discovery of bulb disease symptoms during the lifting of a minor proportion of a collection for routine management such as propagation or re-siting, facilitated by the use of lattice containers. These made it possible to extract and examine individual clumps and even replant them to monitor subsequent changes underground. The symptoms initially seen did not accord with any described in recent texts, so it was decided to send samples of diseased bulbs for expert examination by pathologists at three laboratories, two in the UK, one in The Netherlands.

THE CAUSES OF DISEASE

Stagonosporopsis curtisii (formerly Stagonospora)

This was recognised in 1929 as capable of causing *G. plicatus* bulbs to rot, but not regarded as a major threat to the garden cultivation of snowdrops until the great rise in their popularity over the last two decades. The early significance of *Stagonosporopsis* was as a disease of daffodils where the primary concern was leaf damage, not bulb rot. There have been a number of cases of wholesale losses in major snowdrop collections attributed to this disease, raising widespread concern, which tends to cause many losses of bulbs to be dismissed as due to *Stagonosporopsis* without investigation. This disease can cause bulbs to rot rapidly after the leaves have naturally senesced, so that if lifted in July the bulb can have rotted completely, leaving perhaps only the tunic as an empty shell.

Fusarium oxysporum

Long recognised by bulb growers in The Netherlands as a significant disease of snowdrops, *Fusarium* basal rot or FBR requires control measures. In the UK, however, outdoor field propagation is uncommon, and this fungus as a disease of snowdrops has received scant attention. It is, however, a soil-borne fungus that is widespread worldwide and particular subspecies can cause severe economic losses in a range of crops. In the UK onions, tomatoes and daffodils are affected, forcing growers to use control measures. After killing the plant it has invaded, this fungus can survive in bare soil for 20 years. Rotation, therefore, is not a viable option. In

A SUMMARY OF INFORMATION ON SYMPTOMS OF SNOWDROP DISEASES IN UK AND DUTCH BOOKS AND JOURNALS SINCE 2000

	Stagonosporopsis curtisii	*Fusarium oxysporum*	*Botrytis galanthina*
Common names	Leaf scorch (UK) Vuur (Dutch)	Fusarium basal rot or FBR (UK) Bol rot (Dutch)	Grey mould (UK) Smeul (Dutch)
Foliage symptoms	Year one: grey-green blotches. Year two: brown or red leaf tips, later brown spots.	Light infection: spiky or curved leaves and or tips turn yellow or orange. Severe infection: none.	Plumes of grey fungal strands envelop the leaves and scapes at flowering time causing collapse.
Bulb symptoms	Initially: reddish coloration of scales towards apex. Subsequently: rapid decay of interior. Outer papery scales persist for some time. Bulbs lifted and stored may mummify.	Severe infection: very rapid decay of interior. Outer papery scales persist for some time.	Bulbs turn brown and rot. Within a single clump, only some bulbs may be infected in year one.

this study *Fusarium oxysporum* was positively identified.

Ilyonectria europaea and *I. robusta*

These soil-borne fungi are related to *Fusarium* and, as plant pathogens, appear to share a number of similar characteristics. Their discovery as the cause of infection in this study is due to modern laboratory techniques including DNA sequencing, advances in taxonomy and the expertise of the scientists involved. This is the first identification of these fungi as pathogens of bulbs. They have as yet no common names.

Phoma glomerata

This fungus, not previously recognised as a disease of snowdrops, was also isolated from the samples in this study. The unusual nature of the symptoms at lifting in July – a very dark tunic that is strikingly damp or wet to the touch, yet a bulb that remains firm and, when cut open vertically, is still white within – was the first indication of a serious problem. It seems probable that this symptom is a consequence of infection with *Phoma glomerata* and, in the bulbs studied, it may have visually masked underlying infection by FBR or *Ilyonectria*.

Botrytis galanthina

Most references to this disease cite an experience in the late 19th century when a particularly severe attack devastated the collection of a leading galanthophile of the day. It is not clear whether or not such disastrous attacks have occurred in the ensuing 120 or so years; reported instances since then seem typically to be much more limited in scale. One snowdrop drift or a few individual clumps may show infection in some years. Certainly this has been our experience.

Galanthus elwesii 'Hunton Giant', lifted in mid-June. The tunic is exceptionally dark, damp or wet to the touch. The interior is firm and the white base plate is stained. It is infected by two fungi, *Phoma glomerata,* probably the cause of the abnormal appearance and condition of the exterior, and *Fusarium oxysporum*, commencing its entry through the base plate. *G. reginae-olgae* 'AJM75' and *G. plicatus* 'Hunton Herald' showed identical symptoms.

Usually it is easily diagnosed. The familiar symptoms develop just before the peak of flowering: a mass of grey threads of mycelium from ground level upwards, engulfing both leaves and scapes in a dramatic manner. In some instances signs of infection are

Galanthus reginae-olgae 'AJM75' lifted in mid-October. The tunic no longer exists and the interior is totally rotten, with decay progressing from the base plate upwards (base at the top). *G. elwesii* 'Hunton Giant' and *G. plicatus* 'Hunton Herald' were in a similar condition at this date

Galanthus reginae-olgae 'Tilebarn Jamie' lifted in mid-November. All bulbs are infected with *Fusarium oxysporum,* which by entering through the base plate suppresses or prevents root development. Healthy bulbs of this cultivar would have completed flowering by this date

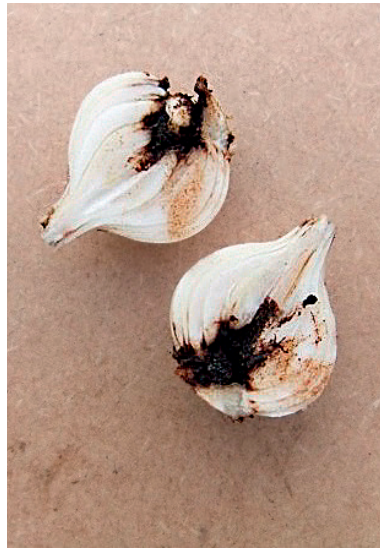
Left, healthy dormant bulbs from a purchased batch of *Galanthus woronowii.* Below left, diseased bulbs from the same batch infected with *Stagonosporopsis curtisii.* In general infected bulbs are darker and close inspection reveals shrivelling. Such bulbs are referred to as mummified. They persist in storage but rot quickly without trace in soil. Below, the interior of a mummified bulb.

less obvious, occurring at ground level when the flower buds have only recently emerged through the soil, and require acute observation to spot a small amount of mycelium. Often its appearance is sudden and development very rapid. To minimise its impact, frequent inspection is vital – at least twice a week.

A recent experience of this disease has been recorded in which no conventional symptoms appeared at all. In this instance an entire drift of *Galanthus ikariae* was wiped out in one season. The only indication of disease was the unexpected non-appearance of the entire colony, which had grown and flowered perfectly in the preceding season. The cause was only discovered when the site was very carefully excavated. All the bulbs were still in position and had started to root. Likewise emergent leaves and flower buds were present. Then suddenly every bulb had died before any leaf or flower had pierced the soil surface. Diagnosis was possible because all bulbs showed the *sclerotia* (hardened fungal mycelium) indicative of *Botrytis*.

IDENTIFICATION OF FUNGI

Everyone who grows snowdrops has experienced losing bulbs in his or her collection, either in the growing



Three bulbs of *Galanthus elwesii* 'Kinn McIntosh' lifted in mid-December. This cultivar flowers early, often in November. These bulbs have become infected by *Ilyonectria europaea* or *I. robusta*. Right, the interior of one of these bulbs showing entry through the base plate, as with *Fusarium oxysporum*.

season or while the bulbs are dormant. Identification of diseases by gardeners relies on leaf symptoms during the growing season. This may be satisfactory for *Botrytis* and *Stagonosporopsis*, which in most literature are listed as the two main diseases from which *Galanthus* suffer. It is only comparatively recently that the development of DNA analysis has made it possible to identify fungi more accurately. Simultaneously it has helped bring about advances in the taxonomy of fungi.

For *Fusarium* and *Ilyonectria* the symptoms may exist only underground, thus lifting the bulbs during the dormant period is a much more reliable method of detection. Therefore we recommend the use of lattice containers wherever possible. This not only makes it easier to lift all the bulbs of one clump without damage but also ensures that, if infection is discovered, no diseased material is accidentally left behind.

COMBATING FUNGI

Chemical control

In the UK the Chemicals Regulations Directorate implements EU legislation covering the use of fungicides. A chemical with an approved commercial horticultural use often does not receive approval for use in gardens. Currently no fungicides relevant to the control of bulb diseases have approval for use in domestic gardens. Commercial bulb

growers often routinely use fungicides to prevent infection or to control disease. This means that healthy bulbs can be obtained. There will be no fungi on or near the bulb, neither fungi causing diseases nor beneficial fungi such as mycorrhiza. But after growing for one season, bulbs become vulnerable to infection again because spores of fungi occur everywhere. Weak plant material is very susceptible to fungi.

In much literature a surprising range of chemicals not sold as fungicides, and therefore not subject to approval under the regulations, is mentioned as having fungicidal properties and as being suitable for use with bulbs. However, there is little evidence to support their efficacy. But where bulb sterilisation is justified, treatment of dormant bulbs with a 95 per cent ethanol solution (the maximum concentration normally obtainable) could reduce the number of fungal spores. Plunge bulbs in this ethanol solution for two minutes then rinse with distilled water.

Hot water treatment

This is a chemicals-free technique developed for commercial growers to control some pests as well as diseases. Clean, dormant bulbs are put for a specific period in a container filled with water at approximately 44C. At this moment there is no literature describing this method for *Galanthus*.

Create favourable conditions

The restrictions on conventional fungicide use in gardens mean that other measures to stimulate disease resistance of bulbs become increasingly important.

These diseases do not invariably cause rapid rotting. Some infected bulbs can remain in the soil for long periods in a comatose condition. This infected bulb was observed to be comatose in December, and did not rot and disintegrate until the following August.

The aim is to provide circumstances that potentially offer the best chances for bulbs to thrive naturally.

- Choose the best spot – wet or dry, shade or sun – with regard to the needs of the species or cultivar.
- Use a good soil or compost for containers and refresh every two years.
- Ensure efficient drainage, especially around and beneath the lattice container.
- Cover the bulbs with a little sharp sand as the leaves die down. This prevents the laying of eggs by narcissus fly.
- Remove any diseased material and bin it.
- Do not damage any part of the plant.
- Starting with dormant bulbs provides the opportunity to modify the new root environment from the outset, either physically (e.g. added compost) or biologically (e.g. adding beneficial fungi).

Five bulbs from a clump of *Galanthus elwesii* 'Advent' lifted in early February. Above ground the symptoms were delayed emergence and weak growth, while below ground there was little or no root growth.

Below left, this bulb from the same clump clearly shows the damaged base plate, a consequence of infection by *Ilyonectria europaea* or *I. robusta*.

Left, the interior of a similar bulb which started root growth before the base plate became wholly infected. Another site of infection can be seen at the neck – this may be a different pathogen.

Mycorrhiza and other beneficial fungi

Much has been written in recent years about mycorrhiza but unfortunately there is no information specific to *Galanthus*. In short, a wide range of plants benefit from symbiosis with certain fungi. The roots of snowdrops, like those of most bulbs, do not produce root hairs. Mycorrhizal fungi are classified in two groups: those which form a sheath around roots and those which enter plant roots. The roots take nutrients from the fungus, while the fungus obtains carbohydrates from the plant and takes up nutrients and water from the soil. The fungus essentially extends the plant's root system.

Disturbance of this delicate association means that the bulb root cannot function as it should do. The plant

weakens and becomes more vulnerable to infection and disease. To benefit from these natural associations requires a non-traditional gardening approach: minimal soil disturbance, thus no digging or hoeing, particularly when the bulbs are dormant. Disturbance destroys the spores of mycorrhizal fungi. An organic surface layer, ideally leaf-mould plus a little lime, helps these fungi thrive. And of course the use of fertilisers, herbicides or pesticides is incompatible with this system.

Like mushrooms, mycorrhizal fungi can be cultivated commercially. A British firm is now supplying a mixture of two of the sheath-forming types and three of the root-entering types as a commercial product for use by both gardeners and growers in two formulations, one targeted at bulbs. For garden use the product is marketed in association with the Royal Horticultural Society. It is necessary to realise that such products have a limited shelf life, in this case 18 months at ambient temperatures. As yet, no experimental evidence is available about the success or otherwise of this 'blunderbuss' mixture for *Galanthus*.

Where snowdrops have become naturalised for many decades, even centuries, for example in churchyards and country estates, they develop a stable ecological status involving mycorrhiza. The general appearance of these often large populations is that they are disease free. Sometimes, on detailed inspection, some disease can be found, but it does not lead to the mass fatalities that can occur where natural defences, such as beneficial fungi, are absent. Currently we are investigating the effect of adding soil from a long-term site of naturalised *Galanthus* into the fresh compost we use for growing our snowdrops. This may be a way of introducing a specific mycorrhizal fungus adapted to *Galanthus*. Mycorrhiza are known to be capable of providing protection from disease.

In addition to mycorrhiza, a Dutch company is commercially producing and marketing to growers and gardeners the beneficial fungus *Trichoderma harzianum*. Originally considered to offer biological control of certain pathogenic fungi, its additional advantage of protecting the roots, enabling them to develop rapidly and unchecked by hostile elements, is now being rapidly exploited in the marketplace. The current product, based on strain T-22, is increasingly used in commerce, particularly by glasshouse growers for seed-raised crops. Snowdrop bulbs, which renew their entire root systems annually, could possibly benefit in the same way. The shelf-life of this product is quite short – four months in refrigerated storage at 4C. As yet no experimental evidence of its suggested beneficial influence on the maintenance of healthy snowdrop root systems is available.

The source of newly acquired snowdrops is worth considering. If the source is a long-established snowdrop area managed in a way favourable to mycorrhiza, planting 'in the green' may provide more than convenience. It may also provide a means of introducing the appropriate mycorrhiza. But if the bulbs or roots are damaged, the result could be less successful.

Left, the typical symptom of *Botrytis* infection, the development of mycelium on the leaves and scapes creating a grey furry appearance. Below, the symptoms can be less obvious. This cluster of bulbs has only limp foliage, some parts of which are starting to turn grey as the mycelium develops.

Quarantine

After acquiring new plants or dry bulbs they should be kept in quarantine as a safeguard to prevent infection of the plants you already grow. Finding a suitable quarantine site is problematic, and if disease is found a new site may be needed. This problem is particularly acute in small gardens. We suggest the use of pot-grown plants stood on a surface that can be sterilised, such as concrete. For plants acquired at flowering time and then checked as dry bulbs, six months may be long enough. For bulbs acquired when dormant, however, this time span should be doubled.

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