Recently introduced diseases of ornamental plants

Gardens are being increasingly exposed to new diseases, principally due to globalization of plant trade. BÉATRICE HENRICOT surveys the most significant introductions

THE MAIN REASONS for increased risks of introducing pathogens into any country are globalization of trade and travel, evolutionary change of plant pathogens, and climate change and in particular its effect on insects as disease vectors (Waage *et al.* 2007). Globalization is probably the main driver of increased risk of introducing plant pathogens in the future and this has been well documented (Brasier 2005, Henricot & Gorton 2005, Ingram 2005, Brasier 2008). Pathogen evolution is a continuous process but has been accelerated by modern plant trade. Nurseries are now prime grounds for species mixing and exposure to new hosts. On the other hand, climate change may have mixed effects on disease establishment.

One key question is whether we are recording more new diseases than in the past as a result of these factors. A study carried out by Jones & Baker (2007) indicated that the numbers of new or important pathogens establishing in the UK during the period 1970–2004 are not increasing. A total of 234 new pathogens were recorded during that period and were mainly associated with ornamental plants (as opposed to horticultural crops, wild native species, agricultural crops, pasture plants, and exotic forestry tree species). Although the rate of establishment appears to be stable, the pressure from newly introduced pathogens is increasing.

The problem of epidemics caused by introduced plant pathogens is not new and infamous examples include potato blight in the 19th century and Dutch elm disease in the late 1960s. More recently, gardeners have had to deal with box blight and new species of *Phytophthora* such as *P. ramorum* and *P. kernoviae*.

This article will look at diseases which have recently been found in gardens in the UK. Cases mainly come from the RHS advisory records since 1998 with some additions taken from the online journal *New Disease Reports* (www.bspp.org.uk/publications/new-disease-reports). The RHS records are based on samples received from UK gardens and can be considered as good barometers of successful establishment of ornamental plant diseases.

Photographs: Horticultural Science, RHS

Blight and leaf spot *Cylindrocladium buxicola* on *Buxus* (left) and *Elsinoë mattiroloanum* on *Arbutus* (right)

Leaf spot An unidentified *Septoria* species on *Escallonia*, the first case in the UK was recorded in 2007

Leaf spot and blight fungi

Leaf spotting fungi are the most numerous introduced pathogens (Jones & Baker 2007). Most cause minor damage on plants but a few diseases caused by these fungi have recently caused concern among gardeners including box blight, and *Arbutus* and *Escallonia* leaf spots.

The box blight pathogen *Cylindrocladium buxicola* was first reported in the UK in 1994 (Henricot & Culham 2002). The fungus causes leaf spot and stem dieback and has only been recorded on *Buxus* species. It is a new fungal species whose origin is unknown. It was either introduced on imported nursery stock or on wild plant material brought in by plant collectors. Since its introduction to the UK the fungus has spread rapidly through Europe where it causes epidemics in favourable environments and also threatens native *Buxus*. Outside Europe the fungus has only been recorded in New Zealand.

In the same genus, the fungus *Cylindrocladium pauciramosum* is also a new appearance in this country (Lane *et al*. 2006a) although unlike *C. buxicola*, this species was probably in the country for a significantly longer period before it was recorded. Although affecting a much wider range of host of plants so far, it has caused little problem for gardeners.

Symptoms caused by *Elsinoë mattiroloanum* on *Arbutus* were first recorded in 1998 through RHS samples, but the first case in the UK was recorded in 1978 (Jones & Baker 2007). The symptoms are extremely disfiguring, causing purplish-black spots on the leaves and infected leaves drop readily. Young stems are also affected. It is not clear how the disease came to the UK but the climate seems to be favourable for its establishment as a high number of trees with symptoms are now being recorded.

Another species in the same genus, much more recently recorded and potentially quite disfiguring on its only host (*Quercus ilex*), is *Elsinoë quercus-ilicis*. The fungus was first reported at Royal Botanic Gardens, Kew, by Spooner (2009). It is widespread on the continent and has been recorded on a few occasions in gardens. In Guernsey, *Quercus ilex* is particularly affected by this disease. Trees are heavily defoliated as a result of infection.

Leaf spots on *Escallonia* are a recent problem in the UK. The first cases were recorded in 2007 and the disease is on the increase. It has been recorded on established *Escallonia* in gardens but also on nursery stock. Two fungi are associated with the leaf spots, a *Septoria* species and a *Cercospora* species, which have not yet been identified to species. It is not clear where the diseases came from, although fungi in both genera have been recorded on *Escallonia* in South America. Both fungi cause purplish brown leaf spots and the young shoots suffer from dieback.

Powdery mildews

Powdery mildews are ubiquitous plant pathogens and can be recognized as a white coating on leaf surfaces and other aerial parts. Some species are regarded as invasive because they spread rapidly from their point of introduction. Early examples of invasive powdery mildews are *Erysiphe necator*, grape powdery mildew, and *Podosphaera mors-uvae*, American gooseberry mildew. Both were introduced to Europe in the 19th and early 20th centuries from North America (Kiss 2005).

More recent cases are *Erysiphe azaleae* infecting *Rhododendron* and introduced to Europe in 1981, probably originating from North America or Asia (Inman *et al*. 2000); *E. symphoricarpi*, a North American species infecting *Symphoricarpos*, recorded in the UK in 1999 (Kiss *et al.* 2002); *E. flexuosa* on *Aesculus* recorded in the UK in 2001, probably originating from North America (Ing & Spooner 2002); *E. elevata* a North American species infecting *Catalpa*, recorded in the UK and other European countries in 2002 (Cook *et al.* 2004); and *E. deutziae* on *Deutzia*, introduced from Asia to mainland Europe and then UK in 2006 (Denton & Henricot 2006).

In some cases, new species of ➤

powdery mildew of unknown origin have arisen in the UK. Examples include two new *Erysiphe*, one on various *Crassulaceae* (Henricot 2008) and one on *Calluna* (McQuilken *et al*. 2002), and a new *Podosphaera* on *Cuphea* (Beales & Cook 2008).

Another process that leads to new powdery mildew diseases is host jumping. This is part of the evolutionary process of powdery mildews and new hosts have been recently recorded. The process could have been accelerated by human intervention causing potential hosts to overlap in gardens, or because the hosts overlap in the wild. A recent example of host jumping is the UK record of *Neoerysiphe galeopsidis* on *Catalpa* in the *Bignoniaceae* (Cook *et al.* 2006a) and *Acanthus* in the *Acanthaceae* (Cook *et al*. 2006b). Prior to these records, *N. galeopsidis* was only found on *Lamiaceae*. Another example that illustrates this phenomenon is wisteria powdery mildew, recorded in the UK for the first time in 1999. DNA analysis indicated that it is almost identical to *Erysiphe alphitoides*, the cause of oak powdery mildew (Henricot & Cook 2008). Further research involving cross inoculation assays is currently supporting this hypothesis.

Oomycetes

Oomycetes are related more closely to algae than fungi and include some of the most important groups of plant pathogens that cause diseases. Gardeners know them as phytophthora blight, root rot, damping-off, downy mildew, and white blister.

In the last 20 years, numerous new *Phytophthora* species have been recorded in the UK, all probably imported on nursery stock (Brasier 2009). Early introductions include *P. infestans* and *P. cinnamomi*, the former being the cause of potato and tomato blight. More difficult to diagnose, and less familiar to gardeners, is *P. cinnamomi*, a cause of root rot on many ornamentals. Nevertheless, *P. cinnamomi* was also introduced to Europe in the 19th century and probably originated in the South Pacific. It caused epidemics in UK nurseries in the 1960s and 1970s and infects more than 3,000 hosts (Brasier 2008). According to a RHS survey it is the third most common *Phytophthora* recorded in gardens and has been found on at least 34 ornamental genera, most commonly on *Taxus baccata*.

Jones & Baker (2007) identified 14 species of *Phytophthora* introduced to the UK between 1970 and 2004. Another three, *P. niederhauserii*, *P. quercina* and *P. tropicalis*, can be added to this list, making a total of 17. Among them, 12 species have been recorded more than once by the RHS survey and may therefore be considered as established in gardens. Examples of these include *P. ilicis*, holly blight; *P. alni*, causing a lethal disease of *Alnus*; *P. citrophthora*,

Powdery mildews *Neoerysiphe galeopsidis* on *Acanthus* (top left), *Erysiphe elevata* on *Catalpa* (above left), wisteria powdery mildew on *Wisteria* (centre) and *Erysiphe deutziae* on *Deutzia* (right)

Oomycetes *Phytophthora ramorum* on *Rhododendron* (above left), *Phytophthora ilicis* on *Ilex aquifolium* (above right) and *Phytophthora cinnamomi* on *Taxus baccata* (right)

causing root rot on many ornamentals; and *P. rubi* and *P. idaea* both causing root rot on raspberry.

Recently, the newly recognized species *P. ramorum* and *P. kernoviae* are causing much concern. Both are quarantine organisms and are subject to eradication or containment. The symptoms of both include leaf blight, twig dieback and bleeding cankers. *Phytophthora ramorum*, first recorded in the UK in 2002, has a very wide host range. It has been reported on at least 70 genera in 33 families (Anon. 2008). The type of hosts varies between countries. In the US it has caused the death of thousands of oak trees (hence its name, sudden oak death). But in the UK the pathogen is mainly found on shrubs such as *Viburnum*, *Camellia* and *Rhododendron* with *Fagus sylvatica* being the main tree affected.

Phytophthora kernoviae was first found in the UK in 2003. The only other country where the pathogen has been reported is New Zealand, where it has been present since at least the 1950s but does not appear to be associated with disease symptoms. In the UK, the spread of *P. kernoviae* has been more restricted than that of *P. ramorum* but it is considered to be more aggressive and has already spread to heathland environments. It has been reported on 15 host genera in nine families (Anon. 2008). The main shrub affected is *Rhododendron* and the main tree is *Fagus sylvatica*.

Pythium is closely related to *Phytophthora* but is relatively unknown as a plant pathogen. The most common diseases caused by *Pythium* are damping-off of seedlings and root rot but most of them are regarded as saprophytes. The group is understudied and, due to the difficulty of isolating these soil organisms, it is not easy to ascertain whether some species now recorded in the UK were introduced in the past or have always been present and just unnoticed. An example of this is *P. attrantheridium* which was reported as a new species in 2004 in Canada and the US. There it is regarded as a native pathogen, possibly playing a significant role in apple and cherry replant problems in the US (Allain-Boulé *et al.* 2004). Since its discovery, *P. attrantheridium* is now commonly recorded in British gardens, and is found associated with root rot and leaf blight symptoms on 39 genera. More research is needed to explore its origin and pathogenic status, but it seems reasonable to assume that this species was already present and the increased use of molecular tools and intensification of screening for pathogens such has *Phytophthora* has allowed its discovery.

Downy mildews are another important group of oomycete plant pathogens. They cause yellow or discoloured areas on the upper leaf surfaces and produce off white mould on the corresponding under surfaces. Several species have been introduced to the UK (Jones & Baker 2007) and a couple of native species have expanded their natural host range (Lane *et al*. 2006b, Humphreys-Jones *et al*. 2008), but only a few appear to have become ➤

SOME RECENT INTRODUCTIONS TO THE UK OF ORNAMENTAL PLANT DISEASES				
Pathogen name	**Host**	**Date of introduction or first UK record**	**Importance in the UK**	**Recorded by RHS**
Leaf blights, spots & anthracnose				
Cylindrocladium buxicola	*Buxus*	1994	high	yes
Cylindrocladium pauciramosum	*Ceanothus*	2002	low	yes
Discula destructiva	*Cornus*	1993	mid	yes
Elsinoë mattiroloanum	*Arbutus*	1978	high	yes
Elsinoë quercus-ilicis	*Quercus ilex*	2003	mid	yes
Phaeophleospora phormi	*Phormium*	1983	low	yes
Phloeosporella ceanothi	*Ceanothus*	2001	low	yes
Pseudocercospora cladosporioides	*Olea*	2005	low	yes
Septoria betulae	*Betula*	2004	low	no
Septoria cercidis	*Cercis siliquastrum*	2007	mid	yes
Septoria species and *Cercospora* species	*Escallonia*	2007	high	yes
Powdery mildews				
Erysiphe azaleae	*Rhododendron*	1980	high	yes
Erysiphe catalpae	*Catalpa*	1990	low	yes
Erysiphe deutziae	*Deutzia*	2006	mid	yes
Erysiphe echinopis	*Echinops*	1990	low	no
Erysiphe elevata	*Catalpa*	2004	high	yes
Erysiphe flexuosa	*Aesculus*	2002	mid	yes
Erysiphe magnicellulata	*Phlox*	1990	low	data deficient
Erysiphe symphoricarpi	*Symphoricarpos*	1990	low	data deficient
Erysiphe syringae	*Ligustrum*	1990	low	data deficient
Erysiphe species	*Crassulaceae*	2007	mid	yes
Neoerysiphe galeopsidis	*Catalpa*, *Acanthus*	2004 & 2005	high	yes
Podosphaera verbenae	*Verbena*	1994	low	data deficient
Podosphaera species	*Cuphea*	2007	low	no
Erysiphe arcuata	*Carpinus*	not formally recorded	mid	yes
Erysiphe species	*Calluna*	2000	low	no
Rusts				
Puccinia heucherae	*Heuchera*	2004	mid	yes
Oomycetes				
Albugo trianthemae	*Aizoaceae*	2007	mid	yes
Peronospora belbahrii	*Agastache, Ocimum, Solenostemon*	2009	high	yes
Peronospora myosotidis	*Brunnera*	2004	low	no
Phytophthora alni	*Alnus*	1993	high	yes
Phytophthora ilicis	*Ilex*	1989	high	yes
Phytophthora inflata	several	1991	mid	yes
Phytophthora kernoviae	several	2003	high	no
Phytophthora niederhauserii	several	2006	low	yes
Phytophthora ramorum	several	2002	high	yes
Phytophthora tropicalis/capsici	several	2006	low	yes
Plasmopara obducens	*Impatiens*	2003	high	yes
Pythium attrantheridium	several	2006	high	yes
Bacteria				
Pseudomonas syringae pathovar *aesculi*	*Aesculus*	2001	high	yes
Viruses				
Canna yellow mottle virus & Canna yellow streak virus	*Canna*	1999 & 2005	mid	yes
Hellebore net necrosis virus	*Helleborus*	1990s	high	yes
Impatiens necrotic spot virus	several	1994	high	yes



Oomycete downy mildews *Pythium attrantheridium* on *Osmanthus* (left), *Plasmopara obducens* on *Impatiens* (centre) and *Albugo trianthemae* on *Lampranthus* (right)

established in gardens. The most damaging introduced species is probably *Plasmopara obducens*, the cause of impatiens downy mildew. This was introduced to the UK in 2003 (Lane *et al*. 2004) and is likely to have arrived on imported commercial propagation material. Statutory action was taken in the UK against confirmed outbreaks of the disease but this approach was discontinued, and the summers of 2007 and 2008 saw its most widespread outbreaks.

White blister diseases, also called white rusts, include a small group of diseases caused by fungus-like organisms in the genus *Albugo*. The only recent introduction that appears to have established in gardens is *A. trianthemae* (Henricot *et al*. 2009). This species affects members of the *Aizoaceae* such as *Delosperma* and *Lampranthus*, leading to death of the host .The first time it was reported in Europe is in the UK in 2007 but this species occurs in many other areas of the world.

Bacteria

An early example of an introduced bacterial disease is *Erwinia amylovora*, the cause of fireblight on *Pyracantha*, *Sorbus* and other members of the *Pomoideae* subfamily of *Rosaceae*. The disease originated in the US and arrived in the UK in 1957. In gardens it is now relatively unimportant but, depending on the weather, occasional epidemics still occur. More recent introduced bacterial pathogens have been reported by Jones & Baker (2007) but only three are important on ornamentals.

From the RHS records, only *Pseudomonas syringae* pv. *aesculi* is reported commonly in gardens. It is the cause of epidemics of bleeding canker on *Aesculus* in the UK and other European countries (Webber *et al*. 2007). It causes a bark infection which may eventually cause the tree to decline. Until recently, it was only known to occur in India where is it has been associated with leaf spots symptoms on *Aesculus indica*.

Viruses

Viruses are amongst the smallest of living organisms and can only be detected with the aid of specialist equipment, and few laboratories are equipped for this. They induce a range of symptoms including reduction in growth, mosaics, mottles, ringspots, line pattern, necrosis and malformations. In non-commercial situations, viruses will usually not be confirmed and a diagnosis will be proposed based on symptoms and cultural conditions. It is difficult, therefore, to ascertain how many, out of the introduced 26 new viruses listed by Jones & Baker (2007), are in gardens.

One notable example is *Impatiens necrotic spot virus* which was first reported in the UK in 1994 (Weekes *et al*. 1998). It can affect more than 300 species in 50 families, particularly *Begonia*, *Cyclamen*, *Fuchsia*, *Gloxinia* and *Impatiens*, and even weeds. It is transmitted by thrips, particularly western flower thrips, *Frankliniella occidentalis*, itself introduced from North America. The virus is predominantly a problem in glasshouses, as western flower thrips cannot currently survive winters outdoors in the UK. But with warmer winters forecast due to climate change, the vector and virus could be on the increase in the future.

An example of a new virus first detected in the UK, in 2007, is *Canna yellow streak virus*. It is associated with severe streaking symptoms and was one of the viruses that caused the destruction of the entire National Plant Collection of *Canna* (Monger *et al*. 2007). The origin, mode of transmission or full host range of this virus is not known.

Helleborus net necrosis virus is ➤

Bacteria and viruses Bleeding canker on *Aesculus* (left), *Impatiens necrotic spot virus* on *Hoya* (centre) and *Canna yellow streak virus* on *Canna* (right)

another new virus that has established in gardens. Better known as hellebore black death, the disease has been recognized in the UK and other countries for the last 20 years. Its cause has been difficult to prove but a new carlavirus associated with the symptoms has been recently described (Eastwell *et al*. 2009). Its mode of transmission is still unproven but the virus belongs to a group that is aphid-transmitted. The symptoms are black spots or streaks on the leaves, stems and flowers. The plants become stunted and may die. This disease is mainly found on cultivars of *Helleborus* x *hybridus*.

Conclusions

Accurate and timely reports of new host-pathogen records are essential for diagnostics and identification, management, and prevention of plant diseases. Many ornamental plant pathogens are poorly known and they may be introduced and established before their impact on the environment is understood.

The question arises as to how gardeners can do their part to limit the risk of introducing these new organisms. The plant trade has a role to play in this, but gardeners as consumers can also make choices which can influence how the trade operates. First of all, being aware of the origin of plants and choosing home-grown plants would alleviate the problem. To help consumers make the right choices, it has been suggested that a traffic light system, similar to the nutritional one for food, be introduced. This could curb the trend for demanding new and exotic plants. Another way to limit introductions of pathogens is to quarantine newly purchased plants before planting them out. This is because fungicides used in nurseries can have a suppressant effect, so some disease symptoms can be expressed within a month of purchase once the regular application of fungicide has ceased. Avoiding 'instant impact plants' would also help, as this has resulted in a growing trend for importing mature specimens which are more likely to carry diseases. The root ball of these specimens includes a diverse non-native microbial community that cannot be inspected adequately.

Many of these factors are reminders that sourcing plants in an environmentally friendly way is becoming increasingly challenging.

Hellebore black death, caused by *Helleborus net necrosis virus*, mainly affects *Helleborus* x *hybridus*

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