# *Phytophthora ramorum*

## A threat to our trees, woodlands and heathlands

### What is it and where is it found?

*Phytophthora ramorum* is a serious fungal pathogen causing damage to trees and a range of native plants in California and Oregon, USA. In North America it is now also affecting a range of ornamental plants in many US states and in Canada. In Europe, it has been found in many countries such as Belgium, Denmark, France, Germany, Italy, the Netherlands, Norway, Poland, Republic of Ireland, Slovenia, Spain, Sweden, Czech Republic and UK including the Channel Islands where it is mainly affecting ornamentals in nurseries, but has also been found on a few individual trees and some established plantings of various shrub hosts (mainly rhododendron) in a limited number of countries. In both the USA and Europe, the pathogen is considered to have been introduced separately and relatively recently, possibly from Asia. There are distinct North American and European populations, although both belong to the same species.
Both populations appear to have the same potential host range, but have been found to differ in their aggressiveness to tree hosts. In laboratory tests, European isolates have shown to be generally more aggressive. The pathogen exists as two separate 'mating types' (A1 and A2) and sexual reproduction can only occur if these two types come together. If this mating system is functional this would result in potentially long-lived spores, making control of the disease much more difficult and potentially creating greater variability. To date, all UK isolates have been the A1 mating type, as have most European isolates although a single A2 type isolate has been found on the continent. All US woodland isolates have been of the A2 mating type but European A1 isolates have been found recently on nurseries in North America.

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# Why the concern and what are the hosts?

In the USA, the disease has reached epidemic proportions in California where it is causing death of tanoak (*Lithocarpus densiflorus*), coast live oak (*Quercus agrifolia*), Californian black oak (*Q. kellogii*), and interior live oak (*Q. parvula var. shrevei*) and is commonly known there as sudden oak death. *P. ramorum* has also been found on a wider range of other native American plants, causing either 'ramorum dieback' (e.g. Pacific rhododendron, huckleberry (*Vaccinium* sp.) and madrone (*Arbutus* sp.)) or 'ramorum leaf blight' (e.g. Californian bay laurel (*Umbellularia* sp.). These shrub hosts are important in providing inoculum for initiating and maintaining tree epidemics. The pathogen has also caused a needle- and shoot-dieback of Douglas fir (*Pseudotsuga menziesii*), coastal redwood (*Sequoia sempervirens*) and grand fir (*Abies grandis*). Until recently, the pathogen in the USA was considered solely a woodland disease but it has now been found damaging nursery plants (e.g. rhododendron, viburnum and camellia) in several USA states and Canada. In Europe, *P. ramorum* has been found mainly on container-grown rhododendron, viburnum and camellia plants in nurseries. In the UK, the first finding was in spring 2002 on container grown viburnum plants in a nursery; findings on rhododendron and several other hosts have since followed. However, in a few European countries including the UK, it is found mainly on rhododendron shrubs in some established plantings, principally in large public gardens and a few wild (unmanaged) woodland sites. To date, new ornamental hosts in the UK and Europe include species of *Arbutus*, Californian bay laurel (*Umbellularia*), camellia, *Griselinia*, *Hamamelis* (witch-hazel), *Kalmia*, *Laurus* (laurel), *Leucothoe*, magnolia, *Parrotia* (ironwood), *Pieris*, *Syringa* (lilac) and *Taxus* (yew). However, the main threat is to tree species and other ecologically important plants, such as *Vaccinium* species (e.g. bilberry) in native heathland. Experimental work carried out in quarantine facilities has tested more than thirty species of European woodland and plantation trees to assess their susceptibility to *P. ramorum*. This work has indicated that the species at greatest risk in the UK are American northern red oak (*Q. rubra*), Turkey oak (*Q. cerris*), holm oak (*Q. ilex*), European beech (*Fagus sylvatica*), sweet chestnut (*Castanea sativa*), Sitka spruce (*Picea sitchensis*), Douglas fir (*Pseudotsuga menziesii*) and Lawson cypress (*Chamaecyparis lawsoniana*). Although the European oaks such as the deciduous oak (*Q. robur*) and sessile oak (*Q. petraea*) are considered less at risk, some individual trees appear more susceptible than others. Surveys of potentially susceptible trees have now resulted in the first findings on trees in Europe. The first occurrence was on an American southern red oak tree (*Q. falcata*) in the UK followed closely by the first finding in the Netherlands on an American northern red oak tree (*Q. rubra*) in October, 2003. The pathogen has since also been found in the UK causing bleeding trunk cankers primarily on European beech, but also horse chestnut, southern beech (*Nothofagus* sp.) and Turkey oak (*Q. cerris*) and most recently sycamore (*Acer pseudoplatanus*). It has also been found causing a foliar and shoot-blight on holm oak (*Q. ilex*), sweet chestnut (*Castanea sativa*), Winter's bark (*Drimys winteri*) and ash (*Fraxinus excelsior*). On all occasions, the findings on UK trees have been in large gardens in the south of England with infected rhododendrons in close proximity. Initial UK surveys of *Vaccinium* species in heathland have not detected the pathogen. However, some species are considered at high risk, especially *V. myrtillus* (bilberry), which is highly susceptible in laboratory tests, and may potentially be a source of inoculum for susceptible trees where they occur together.

# What are its symptoms?

**On trees**, the pathogen can affect just the bark (e.g. beech), or both bark and leaves and shoots (e.g. tanoak in California); it is also possible that some trees may be just leaf hosts (e.g. ash, which has susceptible leaves, but has not yet been found to have susceptible bark). Bark infections appear most typically as large cankers that have brown to black discoloured outer bark that seep dark-red to blue-black sap (commonly called 'bleeding cankers' or 'tarry spots'). These cankers most typically occur on the lower portion of the trunk. When the outer bark is removed mottled areas of necrotic (dead and dying) and discoloured inner-bark tissue with black 'zone lines' around the edges may be seen. Diseased areas may become colonised by bark beetles. When cankers girdle the trunk, death of the tree occurs resulting in a rapid change in the colour of the foliage. Death can be rapid in some species, e.g. tanoak (*Lithocarpus densiflorus*) in the USA, or may take one or more years, e.g. American *Quercus* species. Cankers do not extend below the soil line and do not appear to infect the roots. Leaf infections most commonly appear as brown necrotic areas, often at the edge or tip of the leaf. On broadleaf tree hosts in Europe, leaf and shoot infections have to date been found on holm oak, ash, Winter's bark and sweet chestnut.

**On conifers** the pathogen causes a needle blight and dieback of young shoots of Douglas fir, coastal redwood and grand fir.

**On yew**, symptoms are a needle blight of the young foliage resulting in an aerial dieback.

**On rhododendron**, *P. ramorum* causes a shoot/twig and leaf blight. Affected shoots or twigs develop a brown to black discoloration that spreads along the twig and can spread into the leaves via leaf petioles (leaf stalk). Characteristic symptoms include blackening of the petiole leaf base and leaf tip and may extend along the mid-rib. Twig cankers can lead to wilting of shoots; in such cases leaves remain attached but may not develop any spots. Leaf infection can also occur without twig infection. Roots are unaffected. Symptoms are similar to those caused by other *Phytophthora* spp. on rhododendron, but the development of symptoms can be more rapid.

**On viburnum**, infection commonly occurs at the stem base causing wilting and then death. The pathogen may also cause brown to black leaf infections, especially on evergreen species and can also affect flowers. It has been isolated from roots associated with stem-base lesions, but root infection has not been proven.

**On Pieris**, it causes brown stem lesions that lead to aerial dieback and leaf symptoms as described on rhododendron.

**On *Hamamelis* (witch-hazel) and *Parrotia***, symptoms are similar to rhododendron, but symptoms on leaves mainly occur at the tip and edge and are delimited by the veins.

**On camellia, Californian bay laurel, *Griselinia*, *Kalmia*, magnolia, *Laurus* (laurel), *Syringa* (lilac)** and ***Leucothoe***, the pathogen usually only causes leaf infections. Leaf lesions are usually brown to black areas, typically occurring at the tip or edges of the leaves. On camellia, some shoots have also been found infected leading to dieback. Several other hosts such as *Calluna*, *Pyracantha* and *Photinia* have been reported as natural hosts for *P. ramorum* in nurseries and Californian wood rose (*Rosa gymnocarpa*) has been reported as a natural wild host in the US; although to date these hosts have not been found infected in the UK.

# *Phytophthora ramorum* – What does it look like?

**Trees**

Bleeding canker on *Quercus falcata* (American southern red oak)

Stem lesions on *Nothofagus sp* (southern beech)

Ash *(Fraxinus excelsior)* infected foliage

Holm oak *(Q. ilex)* infected foliage

Photographs courtesy of Forest Research

# *Phytophthora ramorum* – What does it look like?

## Ornamental Plants

Rhododendron aerial dieback and petiole and leaf base necrosis (inset)

Camellia leaf blight

*Pieris* dieback and leaf necrosis (inset)

*Taxus* (yew) needle blight of young shoot

Photographs courtesy of Central Science Laboratory

## How does it develop and spread?

As *P. ramorum* has only recently been described, our knowledge of disease development and spread is limited but is improving following research. Two different types of asexual 'spores' are formed: sporangia (considered to be involved in pathogen dispersal) and chlamydospores (involved in survival). The type and amount of spores produced is affected by the host, light, temperature, humidity and nutrient status. Both types of spores may be produced on leaves of susceptible hosts, but as yet have not been observed directly on bark cankers on trees. Leaf hosts are therefore likely to be important providers of inoculum for initiating and maintaining tree epidemics. Symptom expression on leaves appear rapidly after three days under optimum conditions although this may be delayed by cooler conditions. The development of bleeding bark cankers occurs more slowly with symptoms probably occurring several weeks or months after infection. Experiments have shown that susceptibility of hosts may vary according to season and whether or not plants are wounded. Tests also showed that bark thickness and resin appeared to play a role. Necrosis occurred most frequently in thin-barked species such as European beech, sweet chestnut and red oak. The fungus is regarded as a cool-temperate organism with an optimum temperature for growth on agar plates of around 20°C and a minimum and maximum temperature for growth of 2°C and 30°C respectively. Sporangia and chlamydospores are robust and able to survive extremes of temperature and pH. For example, in laboratory experiments chlamydospores have been found to survive and germinate on agar after a treatment of –2°C. In the UK, the pathogen has been found to survive in plant debris for two consecutive winters in quarantine contained experiments and field observations but quite possibly longer based on likeness to other species of *Phytophthora*. The pathogen is thought to be dispersed locally by rain splash, wind-driven rain, irrigation or ground water. It has been recovered throughout the year from plant debris, water courses and soil up to a depth of 15 cm at infected sites. Ongoing research at a number of sites has detected spores in rain-splash traps but not moving in the air in the absence of rain. Long distance spread may be by movement of contaminated plant material, growing media, and in soil carried on vehicles, machinery, footwear or animals.

## What is being done in the UK?

Defra's Plant Health and Seeds Inspectorate, the Forestry Commission, SEERAD and DARDNI are carrying out extensive surveys to check for the presence of the organism. Statutory action is being taken whenever the pathogen is found. Measures include destruction of affected plants, tracing of related stocks to contain outbreaks on horticultural plants moving in trade, and increased monitoring of imported host plants. A national survey of over 1,000 woodland sites was completed by the Forestry Commission in April 2004. All samples tested were negative for *P. ramorum*. The full survey report can be viewed on the Forestry Commission website. Defra, the Forestry Commission, the Horticultural Development Council and European Union have commissioned research to investigate the biology, epidemiology and management of *P. ramorum*. For example, laboratory tests have been carried out to determine potential susceptibility of plants. This has been used to help predict plants at risk, leading to the finding of *P. ramorum* on new hosts such as *Pieris*, *Leucothoe*, camellia, holm oak, ash and beech.

## Keep a good look out

*Phytophthora ramorum* is a notifiable pathogen resulting in statutory action to prevent its introduction and spread.

**If you suspect the presence of this disease on your premises, in England and Wales you should immediately contact your local Defra Plant Health and Seeds Inspector or the PHSI HQ, York.**
**Tel: 01904 455174 Fax: 01904 455197**
**Email: planthealth.info@defra.gsi.gov.uk**
**Website: www.defra.gov.uk/planth/ph.htm**

**or, in Scotland contact the SEERAD Horticulture and Marketing Unit, Edinburgh**
**Tel: 0131 244 6303**
**Fax: 0131 244 6449**
**Email: hort.marketing@scotland.gsi.gov.uk**
**Website: www.scotland.gov.uk**

**or, in Northern Ireland, contact the DARDNI Helpline on 028 9052 4999**
**Website: www.dardni.gov.uk**

**In England, Wales and Scotland, if you suspect the presence of the disease on trees you should contact the Forestry Commission Plant Health Service, Edinburgh.**
**Tel. 0131 314 6414**
**Fax: 0131 314 6148**
**Website: www.forestry.gov.uk**

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