

Phytophthora lateralis

looming **large** over UK arboriculture

When a European strain of *Phytophthora ramorum* appeared on container-grown yew trees in 2002 everyone feared for the future of English oak because the same fungus-like pathogen, albeit a different strain, was decimating native North American oaks in the Pacific North West. *Quercus* is a large and varied genus and these oaks were significantly different from our two native white oaks (*Quercus robur* and *Quercus petraea*) which subsequently escaped largely unscathed. Some infection occurred in other UK commercial forest tree species including common beech and sweet chestnut, but the biggest threat appeared to be in the horticulture and arboriculture sectors, due to the number and variety of ornamental trees and shrubs infected in plant nurseries. Within a relatively short space of time infections were recorded on 130 species in 75 different genera across 37 plant families.

Infections were subsequently contained within, and largely eradicated from, UK nurseries which prevented potential disaster in the wider horticulture and arboriculture sectors. The pathogen did escape into the wider environment and onto the invasive shrub *Rhododendron ponticum* and *Vaccinium myrtillus* (wild bilberry), an important heathland ground cover plant, subsequently moving onto a mainstream commercial conifer (Japanese larch) and becoming the most damaging disease of UK commercial forestry.

Dr Terry Mabbett looks here in more details at recent events.



Aerial surveys pick up disease by recording changes in the colour of normal healthy foliage which are quite obvious and startling for *Phytophthora lateralis* on Lawson's cypress (Picture courtesy Forestry Commission).

FIRSTS ALL ROUND FOR SCOTLAND

THE FIRST UK APPEARANCE OF *PHYTOPHTHORA LATERALIS* on *Chamaecyparis lawsoniana* (Lawson's cypress) in Scotland is tinged with irony.

The tree is native to the southwest of Oregon and the far northwest of California where it is found from sea level up to 1,500 m in the Klamath Mountain valleys, often alongside streams. Lawson's cypress was discovered near Port Orford in Oregon and introduced into cultivation in 1854 by collectors working for Lawson & Son nursery in Edinburgh. It was named Lawson's cypress by the describing Scottish botanist, one Andrew Dickson Murray (1812-1878).

Within its native North American range, Lawson's cypress is called 'Port Orford cedar', although it is not a true cedar. Lawson's cypress is not a commercial forestry tree in the UK, but provides a light-weight timber valued in many Far Eastern countries, and especially Japan, for making coffins. Let's hope this is not a bad omen for Lawson's cypress, an important exotic conifer on the UK amenity landscape.

CLOSE COUSIN PHYTOPHTHORA LATERALIS ARRIVES IN BRITAIN

The closely related and equally pathogenic (aggressive) *Phytophthora lateralis* was already in the wider environment when it was first identified in Balloch Castle Country Park on the shores of Loch Lomond in Scotland during November 2010. Unlike *P. ramorum*, *P. lateralis* has a very narrow host range although its main host, like Japanese larch, is a coniferous tree. The only difference is that Lawson's cypress (*Chamaecyparis lawsoniana*) is a very minor conifer in UK forestry but the most widely traded conifer, in a wide variety of colourful cultivars, within the horticulture, amenity, garden and arboriculture sectors.

The disease has since been identified at two more locations in Scotland, Greenock Cemetery and another central Scotland location still unnamed due to commercial sensitivity; at Tollymore in Northern Ireland (August 2011) and at Plymouth in Devon. One of the most recent outbreaks occurred in North Yorkshire alongside the River Washburn near Fewston Reservoir and the town of Otley.

Eradication is still the aim of the Forestry Commission (FC), Fera and other cooperating organisations, but the omens are not good. A Pest Risk Analysis (PRA) conducted by the Central Science Laboratory (CSL) in 2006 claimed the

prospects for eradication of *P. lateralis* would be poor if it escaped from nurseries and into the managed environment which it has clearly done.

FIRST FINDING FOR PHYTOPHTHORA LATERALIS IN THE UK

When several Lawson's cypress were found with *Phytophthora lateralis*, a lethal root-infecting tree pathogen, in Balloch Castle Country Park, and with a significant proportion of the park's 80 Lawson's cypress showing equivalent symptoms, Bob McIntosh, Director of FC Scotland, said, "This is a very worrying development. *P. lateralis* is a particularly virulent pathogen, and very few trees survive an attack." The FC believes *P. lateralis* is capable of surviving anywhere in the UK.

From an assumed Asian Centre of Origin *P. lateralis* arrived in the US around 1920 and much more recently in Europe. It was identified in French nurseries in 1999 and in Dutch nurseries from 2004.

P. lateralis inoculum survives in, and can be transmitted by, contaminated soil, which means any potted plant is a potential carrier and not just Lawson's cypress, the main host plant. An imported potted plant is a mini-ecosystem and no system of plant inspection and certification is going to pick up and identify *P. lateralis* inoculum in the soil unless the plant it surrounds is visibly diseased.



Aerial canopy symptoms caused by *Phytophthora lateralis*, in its capacity as a root-infecting disease, are far removed from the infection and destruction of vital vascular tissues (xylem, phloem and cambium) further down in the roots and stem collar of the tree. (Picture courtesy Forestry Commission).



Phytophthora lateralis bark infection has spread a good distance up this Lawson's cypress tree from an initial root and stem collar infection. (Picture courtesy Forestry Commission).



Foliar symptoms of *Phytophthora lateralis* on Lawson's cypress in Scotland. (Picture courtesy Forestry Commission).

SYMPTOMS, HOST RANGE AND MANAGEMENT

Foliage on root-infected Lawson's cypress appears lighter in colour before withering and turning reddish-brown. As the infection progresses from the roots and root collar and up the stem, 'tongues' of killed bark become visible through their darker colour. Tree death ensues when the trunk is girdled by infection. Trees become infected when the roots make contact with *P. lateralis* spores in the soil or water. Planting infected plants or using soil-harboured spores are key pathways for disease introduction onto new sites. *P. lateralis* is also spread in water run-off.

FC Scotland was equally concerned about 27 dead and dying English yew trees in the park which underwent tests to establish the cause of their condition. Dr McIntosh said, "Although the main victim is Lawson's cypress, it can kill other species, particularly Pacific yew (*Taxus brevifolia*) which is a close relative of our native English yew (*Taxus baccata*) and an established host in western North America."

The dead and dying yew trees were subsequently attributed to *Phytophthora cinnamomi*, first described infecting trees in Britain in the 1930s and with a history at Balloch. English yew is especially susceptible to *P. cinnamomi*. It can persist in soil for years, even after infected plants have been removed, to infect a wide range of trees and other plant types.

Dr McIntosh said, "We are working closely with West Dunbartonshire Council to fell and destroy [by burning or deep

burial] dead and dying trees and to implement biosecurity measures in the park to minimise the risk of spreading the disease. The pathogen is transmitted in soil, on footwear and via pruning and cutting tools. Biosecurity measures include disinfectant mats at park exit points and notices warning visitors to stay on footpaths, keeping dogs on leads and not to remove plant material from the park." Fungicide soil drenches are effective in nurseries but not feasible in the wider landscape where use would also raise environmental issues.

HOW AND FROM WHERE DID PHYTOPHTHORA LATERALIS ARRIVE?

The FC was unable to confirm how *P. lateralis* arrived at Balloch but said it could be related to a previous programme of work involving clearance of invasive *Rhododendron ponticum*, use of soil and mulch from elsewhere and the planting of hundreds of new trees and shrubs. The FC said they were tracing the origins of this soil and plant material.

How *P. lateralis* got into the UK is unknown but most likely on the soil of root balls or semi-mature trees imported for planting, says the FC. The pathogen was recently found associated with yellow cedar (*Chamaecyparis obtusa* var. *formosana*) in Taiwan, although its main centre of activity is north western North America where it arrived in the 1920s. More recent outbreaks were recorded in France and the Netherlands, the latest in 2010. Intra-EU trade in root-balled or container-grown Lawson's cypress is the most likely mode of entry into the UK (author's comment).



Close-up on foliar symptoms of *Phytophthora lateralis* on Lawson's cypress. (Picture courtesy Forestry Commission).

LATEST LATERALIS OUTBREAK PICKED UP BY ROUTINE RAMORUM SWEEP

The latest confirmed outbreak of *Phytophthora lateralis* on Lawson's cypress in Yorkshire in December 2011 was picked up during a routine aerial survey for *P. ramorum* which is sweeping through Japanese larch (*Larix kaempferi*) plantations in the UK commercial forestry sector.

A Forestry Commission spokesperson told essentialARB how such routine aerial surveys for *P. ramorum* had also identified new infection foci for Red Band Needle Blight caused by *Dothistroma septosporum*. This causal fungal pathogen of RBNB is currently spreading from its traditional Corsican pine host base into Lodgepole pine (*Pinus contorta* var. *latifolia*) and Scots pine.

Aerial surveys pick up possible sites and centres of disease infection and spread from changes in the colour of normal healthy tree canopies which may be the result of disease symptoms. Affected trees are subsequently tested for the presence of disease-causing pathogens.

The FC has now instructed its aerial survey teams to record 'anything and everything' even though designated flight paths will still be dictated by, and pass over, areas at high risk from *P. ramorum*.



The tendency for Lawson's cypress to be planted close together to form hedges and windbreaks makes movement of the *Phytophthora lateralis* pathogen from one tree to another, via the soil, that much easier. (Picture courtesy Forestry Commission).

P. lateralis is on the Alert List of the European & Mediterranean Plant Protection Organization (EPPO) but is not currently listed in the European Union's Plant Health Directive.

IMPLICATIONS FOR ARBORICULTURE AND FORESTRY

The establishment and spread of *P. lateralis* could quickly become an ornamental plant trade nightmare as happened in western North America where the trade in Lawson's cypress collapsed. Lawson's cypress is the most important conifer in the UK ornamental nursery trade and accounted for a significant slice of the £29 million in conifer garden-centre sales 'rung up' in 2006.

The FC estimates that fewer than 150 hectares of plantation Lawson's cypress are in Scotland with less than 2200 hectares in the UK overall. In contrast, Lawson's cypress and its many colourful cultivated varieties are popular in amenity and garden planting and the most important conifers in the UK ornamental plant trade. This means *P. lateralis* could impact as heavily on this industry as it has done in western North America.

Phytophthoras are genetically difficult to distinguish even when using the latest techniques in molecular biology. What's more, hybridisation can occur between two distinct species to generate new genotypes having a wider host range and higher pathogenicity (virulence). There are scores of different *Phytophthora* species and many including *P. ramorum* are present in the UK. *P. cinnamomi* and *P. citricola* had already been identified on Lawson's cypress in the UK and *P. ramorum* was subsequently isolated from one of the diseased Lawson's cypress trees at Balloch Castle Country Park.

NEW DEVONIAN DIMENSION

The August 2011 discovery of *P. lateralis* at Tollymore Forest Park in Northern Ireland, where it affected some 800 Lawson's cypress trees, is the most damaging so far, although one of the most recent findings (October 2011) in a Lawson's cypress hedge on an industrial estate at Plymouth in Devon is probably the most worrying. John Morgan, head of plant health for the Forestry Commission, said, "It is very worrying to find this destructive tree pathogen so far from previous cases in Scotland [and Northern

Ireland]. We are working closely with colleagues at Fera to contain the disease and try to trace where it came from."

One clue to this may lie in a disease event in Brittany in north western France over a year ago and not a million miles [as the crow flies] from the Devon and Cornwall Peninsula. If so, attempts to contain *P. lateralis* may have to face the prospect of air-borne inoculum.

French scientists led by C. Robin isolated *P. lateralis* from Lawson's cypress trees in hedgerows in north western France. Of most concern in this latest French outbreak was evidence strongly suggesting that *P. lateralis* inoculum could also be spread by air-borne movement of spores called 'sporangia' in the same way as for *P. ramorum*.

The infected trees in Brittany were planted in hedgerows and showed foliar symptoms similar to those caused by classic *P. lateralis* root disease. Browning and death of foliage high in the tree has invariably been 'damage caused from a distance' by the destruction of xylem (water conducting) and phloem (soluble food translocation) tissues by infection much lower down in the roots, collar and lower stem of the tree.

However, the aerial (foliage) symptoms displayed on these trees was not associated with root or collar infections and *P. lateralis* was subsequently isolated from lesions on the branches. The authors say such foliar symptoms have only been observed once before at a site on the coast of Oregon State in North Western US where climatic conditions are close to those in Brittany.

Based on these observations, and the presence of deciduous (detachable and air-borne) sporangia, the team suggested that *P. lateralis* was being spread by air dispersal of spores in the same way as *P. ramorum*. With typical scientists' understatement they described this finding of *P. lateralis* associated with aerial spread of spores across the landscape of north western France as a new threat for European countries.

References: C. Robin, D. Piou, N. Feau, G. Douzon, N. Schenck, E. M. Hansen (2010) Root and aerial infections of *Chamaecyparis lawsoniana* by *Phytophthora lateralis*: a new threat for European countries. Forest Pathology DOI: 10.1111/j.1439-0329.2010.00688.x

A NEW CONIFER HOST FOR *PHYTOPHTHORA LATERALIS*

P*HYTOPHTHORA LATERALIS* has been identified at six sites in the United Kingdom; three in Scotland, two in England and one in Northern Ireland. Two of the Scottish sites were identified as Balloch Castle Country Park and Greenock Cemetery, the identity of the third being withheld on the grounds of commercial sensitivity.

All infections in the identified locations were on Lawson's cypress (*Chamaecyparis lawsoniana*) trees so it was reasonable to assume the same for the unspecified site. However, it now appears that the infected trees were not Lawson's cypress as supposed but *Thuja occidentalis** (Northern white cedar).

Scientists at SASA (Science and Advice for Scottish Agriculture) subsequently reported finding *P. lateralis* on three container-grown *Thuja occidentalis* cv. 'Emeraude' submitted to them in February and March 2011 by Scottish Plant Health Inspectors with a request to test for presence of *Phytophthora*. The trees were collected from a nursery in central Scotland from a batch of 60 trees about 1 metre tall that were originally imported from France. More exact details about the location of the nursery were omitted by SASA.

The trees showed a grey-olive discolouration on parts of the foliage with dieback beginning to show on some of the branches. No symptoms were observed on the bark, root collar or roots. PCR testing** (gene sequence identification and matching) gave a positive result for *Phytophthora lateralis* but only on samples taken from the foliage. Root samples tested negative indicating aerial (rather than the usual root infection) and like that described by Robin (2010) on Lawson's cypress at Brittany in France.

The team proceeded to satisfy Koch's Postulates (a definitive test used in plant pathology to prove a specific pathogen is responsible for a disease). The sequence of steps involved is

Forest Research trials with Lawson's cypress as a timber tree on Forestry Commission land in Abinger Forest in the Surrey Hills (North Downs).

culturing the *Phytophthora lateralis* (a fungus-like microbe) on the appropriate selective agar (V8 supplemented with antibiotics to inhibit bacterial colony growth) in petri dishes, using this to successfully re-infect healthy hosts and then finally re-isolating and identifying the pathogen again.

Phytophthora lateralis grew on the agar culture with sparse aerial mycelium and produced sporangia (asexual spores) that were generally ovoid in shape but sometimes distorted. Chlamydospores (big thick-walled and resting asexual spores) were seen after 7 to 10 days. No oospores (sexual spores) were observed.



Thuja occidentalis being used as a 'screen'. This conifer species is more commonly associated with a disease caused by the fungus *Amylostereum laevigatum* responsible for the foliar damage caused to a tree on the right-hand side of the picture. (Picture courtesy Forestry Commission).

Pathogenicity (aggressiveness) of the isolated *Phytophthora lateralis* culture was tested on *Thuja occidentalis* cv. Smaragd and *Thuja occidentalis* cv. Holmstrup, *Chamaecyparis lawsoniana* cv. 'Ellwoodii' and *Chamaecyparis lawsoniana* cv. 'White Spot'. This was achieved by floating 10 leaflets from each potential host in a petri dish containing *Phytophthora lateralis* sporangia at a concentration of 3500 sporangia/ml. Ten leaflets from each potential host were floated in distilled water as a negative control. Petri dishes were kept in a growth room at 20°C with 12-hour light/dark cycle.

The majority of leaflets from all four potential hosts showed discolouration or necrosis after seven days. Affected leaflets were surface sterilised and plated on the same V8 plus antibiotic agar. The resulting fungus-like growth was identified as *Phytophthora lateralis* thus satisfying Koch's Postulates and proving this specific *Phytophthora* was responsible for the initial disease on *Thuja occidentalis* cv. 'Emeraude'.

Until this finding, *Phytophthora lateralis* had only been confirmed on two hosts, Lawson's cypress and Pacific yew (*Taxus brevifolia*). This was the first report of the pathogen on *Thuja occidentalis*.

The authors finished by describing how all infected and surrounding plants at the nursery had been destroyed. However, infection was on the foliage and would therefore have occurred through aerial dissemination of spores as previously described on Lawson's cypress in France where these infected *Thuja occidentalis* trees originated. This means the destruction of infected and surrounding plants may not have been enough to ensure there was no further spread of the pathogen.

Reference: Schlenzig A, Campbell R, Mulholland V, 2011.

Thuja occidentalis: a new host for *Phytophthora lateralis*.

New Disease Reports 24, 8 [http://dx.doi.org/10.5197/j.2044-0588.2011.024.008]

**Thuja occidentalis* (Northern white cedar) is an evergreen conifer native to the north eastern region of North America. The tree was brought to Europe in the 16th century where it is now widely used in amenity and landscape planting especially for screens and hedges. There are more than 300 different cultivars. It is closely related to Western red cedar (*Thuja plicata*), an important commercial timber species in the United Kingdom.

**Polymerase chain reaction (PCR) is a technique of molecular biology used to amplify pieces of DNA (gene sequences) thus allowing exact identification of microbial plant pathogens through gene sequence identification and matching.