Phytophthora ramorum
A biosecurity threat to Australasia

Daniel Hüberli
Centre for Phytophthora Science & Management, Murdoch University

Outline

• Overview
• Distribution
• Morphology & genetics
• Hosts & symptoms
• Biology & epidemiology
• Risk to Australasia
Where did it all begin in California?

- Berkeley
- San Francisco
- Marin
- Monterey
Marin & Monterey: large, high end acreages

Yours for $30M (Aussie dollars)!

1999 – Santa Cruz
As Trees Die, Biologists Battle Back
The Effort to Save and Beat a Fungus That Threatens Oaks, Redwoods and Much More
POPULAR – SOD the band!

What is Sudden Oak Death?

• SOD is an inappropriate name!
• Causes severe mortality of forest native CA / OR tree species
  – Tanoak (*Lithocarpus densiflora*)
    • Not an oak; most susceptible spp.
  – Coast Live Oak (*Quercus agrifolia*)
  – Black Oak (*Quercus kelloggii*)

• Some sites: tanoaks (100%) & coast live oak (45%) deaths
Where is it USA?

= 14 total + 1 Oregon County
~650 km along coastal forest

BUT distribution is PATCHY
(aerial dissemination)
Where does it occur in Europe?

Belgium
Denmark
France
Germany
Ireland
Italy
Netherlands
Norway
Poland
Slovenia
Spain
Sweden
Switzerland
United Kingdom

= 14 countries

Camellia's from California with P. ramorum
Camellia’s DESTROYED
P. Ramorum infested

A parking lot or not?

Nurseries with infested plants

P. ramorum confirmed in:
- 16 US states
- British Columbia, Canada
**P. ramorum** is heterothallic

- All USA isolates are A2 (exception of few recent nursery infestations in Oregon & Washington)
- All European isolates are A1

Not sure if:
- Mating is occurring in nurseries
- Crosses produce viable sexual progeny
  - Difficult to mate (low numbers)
  - High abortion rates
Sporangia- Semi-papillate & highly deciduous (don’t sneeze!)

Chlamydomspores
Growth on agar

- Growth at 2 – 28 °C
- Optimum 20 °C

Morphological differences

Photo: Kelly Ivors
AFLP genotypic variability

- USA pop.: very homogeneous
- Europe pop.: slightly more diverse

Microsatellites confirms:
- differentiation between the 2 pop.
- low variation within a pop.
- European strains found in Oregon & Washington nurseries

Broad host range

- > 90 species affected (USA & Europe combined)
  - 51 genera
  - 29 families (Fagaceae, Ericaceae)
- Trees, shrubs, & herbaceous plants
- Database of worldwide hosts: www.rapra.csl.gov.uk
1) **Stem cankers (Sudden Oak Death):**
   - Stem cankers (i.e. mainly phloem)
   - Cankers often bleed
   - Fatal on adult plants (may take several years to kill)

2) **Foliar blight & twig dieback:**
   - Spots & blotches on leaves, often in combination with twig & branch dieback.
   - Occasional death of juvenile & adult plants.

**Disease caused by Phytophthora ramorum**

**HOSTS**

<table>
<thead>
<tr>
<th>Natural LETHAL</th>
<th>NON-LETHAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oaks:</td>
<td>Bay laurel</td>
</tr>
<tr>
<td>Coast live oak</td>
<td>Bigleaf maple</td>
</tr>
<tr>
<td>CA black oak</td>
<td>Douglas-fir</td>
</tr>
<tr>
<td>Shreve oak</td>
<td>Honeysuckle</td>
</tr>
<tr>
<td>Canyon live oak</td>
<td>Huckleberry</td>
</tr>
<tr>
<td>Tanoak</td>
<td>Maidenhair ferns</td>
</tr>
<tr>
<td><em>Nothofagus obliqua</em></td>
<td>Wood Rose</td>
</tr>
</tbody>
</table>

**Nursery**

- Rhododendron
- Camellia
- Viburnum
- Pieris

**Australian Hosts**

- Scribbly Gum *Eucalyptus haemastoma* - yellowing leaves
- Victorian Box *Pittosporum undulatum* - dying leaves
- Cider Gum Tree *Eucalyptus gunnii* - leaf necrosis (artificial inoculation)
- And lots more: Watch this space!
Tanoak (Lithocarpus densiflora) symptoms

- Stem canker
- Leaf necrosis
- Twig dieback

Tanoak stem cankers are fatal.
Wood rose (Rosa gymnocarpa) foliar symptoms

Hüerli et al. (2004) Plant Disease 88, 430

The mighty redwoods
Coast redwood (Sequoia sempervirens)

Summary of symptoms: all above ground

Lesion stops at soil line
**Rhododendron**

- Stem canker
- Leaf necrosis

Alan Kanaskie, Oregon Dept. of Forestry
Some symptoms from the UK

Bay/Oak association in California
A variety of symptoms on bay leaves

Bay/Oak association in California

- Sporangia collected 25 m up in the canopy
- One infected leaf: up to 5000 deciduous sporangia
Bay/Oak association in California

Large inoculum sources:
- Bay leaves
- Tanoak twigs/leaves (most important in Oregon)
- Redwood needles
- *Rhododendron* leaves/twigs
- *Camellia* leaves
Bay/Oak association in California

Bay

Sporangia

Coast Live Oak
(DEAD-END HOST)

Bleeding canker

< 10 m

Canker margin in phloem

Bay/Oak association in California

Bay

Sporangia

Coast Live Oak
(DEAD-END HOST)

Bleeding canker

< 10 m

Canker margin in phloem
Coast live oak crowns (not so SUDDEN)

Can oak leaves be infected?

Can it sporulate?

Sporangia

Chlamydospores

Life-cycle

NUSERY SITUATIONS?

SEXUAL STAGE
How does it spread?

• Spores moved by rain splash, wind, & streams

• Vectors
  – humans
  – animals
  – tires / equipment

• Transportation of plant material (nursery trade)

Detection methods

• Traditional methods
  – Phytophthora selective media

• Molecular methods (PCR)
  – detecting *P. ramorum* DNA

![Graph showing fraction positives](image)
Prevention is the best cure!

Slash and burn: Eradication
The risk to Australasia

Introduction to Australia?

Origin
Unknown
ASIA?
**Pittosporum undulatum**

After 32 h

Sporangia / leaf lesion

<table>
<thead>
<tr>
<th>Plant species</th>
<th>Bay</th>
<th>Pittosporum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Pittosporum undulatum : Aussie host!**

[Map of Australia showing distribution of Pittosporum undulatum]
New Zealand study

- 16 endemic spp., 3 commercial spp. + 2 Rhododendrons
  - Limited individuals
- Detached inoculations
  - Stem underbark (agar)
  - Leaf dip (zoospores)
- Incubated at 20°C 6 days
- Disease assessment
  - Lesion
  - Leaf sporulation
  - Recovery

Australasian *P. ramorum* risk: PhD project

- Susceptibility /sporulation potential
- Identify asymptomatic hosts
- Model risk & spread
- Compare politics & policy for management
New Zealand study – Leaf lesions

![Graph showing leaf lesions for various species](image)

**Species**
- Agathis australis 1/2
- Agathis australis 2/2
- Brachyglottis repanda
- Corynocarpus laevigatus
- Eucalyptus globulus
- Leptospermum scoparium
- Melicytus ramiflorus
- Nothofagus fusca
- Nothofagus menziesii
- Pomaderris prunifolia
- Prumnopitys spicatus 1/3
- Prumnopitys spicatus 2/3
- Prumnopitys spicatus 3/3
- Pinus radiata
- Dacrycarpus dacrydioides 1/2
- Dacrycarpus dacrydioides 2/2
- Dacrydium cupressinum
- Azalea 1/2
- Azalea 2/2
- Coprosma robusta
- Pseudopanax arboreus
- Rhododendron 1/2
- Rhododendron 2/2
- Fuchsia excorticata 1/2
- Fuchsia excorticata 2/2
- Pittosporum eugenioides

**Lesion area (mm²)**

- Asymptomatic

**Fuchsia excorticata**

- (a) 1x10²
- (b) 1x10³
- (c) 5x10³

**Rhododendron**

- (a) 1x10²
- (b) 1x10³
- (c) 5x10³

**ca. zoospores/mL**
New Zealand study – Sporulation on leaves

New Zealand study – Recovery from leaves
New Zealand study – Stem lesions

- **Fuchsia excorticata potential host**
  - Tree 15 m
  - Widespread in lowland to lower montane forests
  - Loves streams
Concerns for Quarantine

- Asymptomatic sporulation: Leaves and fruits (NZ spp., Rhododendron, Quercus spp., Rosa spp. etc...)
- Asymptomatic roots harbor chlamydospores on Rhododendron
- SIGNIFICANT RISK: Quarantine inspection is visual

Info. sources on SOD

WEBPAGE/NEWSLETTER:
www.suddenoakdeath.org