Heterobasidion parviporum - getting ready for the climatic change

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Two species of *Heterobasidion* occur in Finland

- *Heterobasidion* species are the most important forest pathogens in boreal forests
- *Heterobasidion parviporum* causes butt and root rot on spruce
  - economical losses ca 40 million euros per year
- *Heterobasidion annosum s.str.* kills pines
  - annual losses ca 5 million euros per year
Distribution area of *Heterobasidion parviporum*

- *Heterobasidion parviporum* damages are most severe in southern Finland
  - occurs rarely also in the northern part of the country
- Why not in further north?
  - low temperatures?
  - soil type?
  - short history of intensive forestry?
- *Heterobasidion* problem is even more serious in countries south of Finland
Expected climatic change in Finland

- Climatic change is expected to
  - increase temperatures
  - either increasing or decreasing summer rains depending on the scenario
  - increasing rain during the fall, winter and springtime
- Abiotic factors?
- Novel pathogens?
- Old pathogens?
Winter becomes short

The time of ground frost gets short
harvest damages increase
Rotation time of forests becomes short
Tree growth increases

Summertime is warming

More cuttings during the snowless time

The rate of mycelial growth increases

Production of spores increases

Longer time for sporal infection

The time of mycelial growth increases

Windiness increases

Windfalls increase
Production of spores increases

Amount of losses due to Heterobasidion spp

Harvest damages increase

Rotation time of forests becomes short
Tree growth increases

Summertime is warming
Is there anything to be done?

- Spread of *Heterobasidion* spp. towards north can be stopped by stump treatment
  - How to motivate owners of healthy forest?
- Hardwood can be used to clean up an infected site
  - moose, price of wood, soil type etc...
- Stump removal reduces *Heterobasidion* in infected forest sites
  - remaining roots act as a sources of new infection?
  - effect on the soil minerals is poorly known
- New means for control are still needed
  - diseases of *Heterobasidion*, antagonists, breeding for resistance, damage-avoiding machinery...
Project on *Heterobasidion* viruses

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- The first goal is to understand the ecology and evolution of *Heterobasidion* viruses
  - analyses of single growth sites
  - comparison of worldwide diversity
  - experiments on virus transmission
  - effects to the different species of genus *Heterobasidion*

Photo: Eeva Vainio
Fungal viruses in general

- Most known fungal viruses have dsRNA genomes
  - some form intracellular capsid particles
  - others are naked or associated with membrane structures
- Dispersal between mycelia occurs via fungal anastomosis
- Mycoviruses usually do not affect their host phenotypes
- A virus of *Cryphonectria parasitica* causes hypovirulence of its host
  - routinely used in Europe to control Chestnut blight
- Very little is known about fungal viruses in general
Heterobasidion genets and their naturally occurring viruses in a single forest site

- Samples with ca 2.5 kb dsRNA
- No amplification with specific primers
- Identical sequences
Heterobasidion genets and viruses in a single forest site

- Forest sites are often inhabited by Heterobasidion genets with different sizes
- At least some viruses are able to spread through large Heterobasidion genets
- Also neighboring Heterobasidion genets have been infected
Co-evolution hypothesis of viruses and *Heterobasidion* spp

- *H. ins. T*
- *H. ins. Y*
- *H. ins. N*
- *H. ann. s.s.*
- *H. parv.*
- *H. abiet.*

*Host fungus*  |  *Co-evolving virus*  |  *Promiscuous virus*
### Viruses observed thus far in our studies

<table>
<thead>
<tr>
<th>Fungal host strain</th>
<th>Country of origin</th>
<th>Closest relative in NCBI BlastX search</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>H. par</em> 7R18</td>
<td>Finland</td>
<td><em>H. annosum s.str.</em> partitivirus (P-type)</td>
</tr>
<tr>
<td><em>H. par</em> 99020</td>
<td>China</td>
<td>Cherry chorotic rusty spot associated partitivirus</td>
</tr>
<tr>
<td><em>H. par</em> 06101</td>
<td>Bhutan</td>
<td><em>H. parviporum</em> partitivirus (S-type)</td>
</tr>
<tr>
<td><em>H. ins Y</em> 06111</td>
<td>Bhutan</td>
<td><em>H. parviporum</em> partitivirus (S-type)</td>
</tr>
<tr>
<td><em>H. ins T</em> 05166</td>
<td>China</td>
<td><em>Helicobasidium mompa</em> dsRNA mycovirus</td>
</tr>
<tr>
<td><em>H. abi</em> 04188</td>
<td>Turkey</td>
<td><em>Curvularia protuberata</em> thermal tolerance virus</td>
</tr>
</tbody>
</table>
Similar viruses infect *H. insulare* and *H. parviporum* in Bhutan

- Partitiviruses of *H. insulare* and *H. parviporum* from Bhutan
  - amino acid sequence similarity is about 99%
  - the closest previously known virus from *H. parviporum* has about 85% similarity to these new viruses

- The virus has most probably moved from one species to another one recently, i.e. after the speciation of their hosts

- This case is in accordance with the "promiscuous virus" hypothesis
Transmission of viruses between *Heterobasidion* species *in vitro*

<table>
<thead>
<tr>
<th>Original host</th>
<th>Transmission</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><em>H. par</em></td>
</tr>
<tr>
<td><em>H. par</em> 7R18</td>
<td>+</td>
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<tr>
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<td><em>H. ins T</em> 05166</td>
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</tr>
</tbody>
</table>
Effect of *H. insulare* strain 05166 virus to *Heterobasidion* spp.

- Virus slightly slowed down the growth of *H. insulare*
- Virus slowed down the growth of *H. abietinum*
- Virus increased or did not affect the growth of *H. annosum* NAm S
Transfer of *Heterobasidion insulare* virus to *H. parviporum* and *H. annosum*

- The virus from *H. insulare* isolate 05166 was recently transferred also to Finnish *H. parviporum* and *H. annosum*
  - no data is available about its effect on these hosts
Anastomosis between *H. insulare* and *H. parviporum*

- Incompatible anastomosis reaction can be seen between *H. insulare* and *H. abietinum*
  - the two mycelia fuse for a while before the death of the meeting cells
  - A possible route for virus transmission
A new interesting virus from *H. abietinum*

- Closest relative is a thermal tolerance virus of *Curvularia protuberata*
  - 41% amino acid similarity
  - an endohyte of grass *Dichanthelium lanuginosum*
- A three-way symbiosis of a virus + endophyte + plant is needed for growth in the geothermal soil environment of the grass
  - Márquez et al., 2007: Science 315, 513-515
- Could the *Heterobasidion* virus also have an effect on its host?
  - evidence indicating transfer from *H. abietinum* to *H. parviporum* was obtained last week
  - no data on phenotypic effects are available
Summary

- *Heterobasidion parviporum* and *H. annosum s.str.* are the most important forest pathogens in Finland
- Their importance is expected to increase due to the climatic change
- Stump treatment, tree species rotation and stump removal are used to control them
  - the problem has not been solved
- Species of genus *Heterobasidion* host viruses
  - some of them affect phenotypic characteristics
  - their practical usefulness is under evaluation
Thank you for your attention!