Living With Environmental Change

Learning from Experience of Crop Diseases: the Tree Health & Plant Biosecurity Initiative

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BBSRC

Forestry Commission

defra
Department for Environment Food and Rural Affairs

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E·S·R·C ECONOMIC & SOCIAL RESEARCH COUNCIL

The Scottish Government

Summary of this talk

- Introduction to Tree Health & Plant Biosecurity Initiative
- Lessons from research on crop diseases for forest health
- Progress in research on ash dieback

Tree Health & Plant Biosecurity Initiative

Phase 1. 2011-2013: Capacity & consortium-building

Phase 2. 2014-2017: 7 research projects

- Innovative ways of dealing with pests & pathogens
- Health & resilience of trees, woods & ecosystems
- Collaboration of tree health specialists and others

Phase 3. 2015-2018

- 1 project each on (A) oak and (B) *Phytophthora*

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1. Quarantine: keep undesirables out including “unknown unknowns”

New approaches for the early detection of tree health pests and pathogens

Project lead: Rick Mumford (rick.mumford@fera.co.uk)

Key Objectives:

- Improved tools for early detection of tree pests & pathogens.
- Exploit technical advances in e.g. genomics & engineering.
- Interdisciplinary: plant health + physics, engineering & economics.

WORKPACKAGES:					
1	2	3	4	5	6
Lead: Mariella Marzano, FR	Lead: Steve Woodward, Aberdeen	Lead: Hugh Mortimer, RAL	Lead: Neil Boonham, Fera	Lead: David Hall, NRI	Lead: David Cooke, JHI
Interdisciplinary approaches ('The Learning Platform')	Volatiles Detection	Multispectral Imaging	Spore trapping	Pest Trapping	Water surveillance

2. The perils of monoculture

Conversely, crop diversity slows spread of disease

Modelling economic impact and strategies to increase resilience against tree disease outbreaks

- Construct a novel mathematical modelling framework incorporating
  - epidemiological,
  - ecological, and
  - economic factors
- to determine
  - resilience to disease, and
  - supply of ecosystem services.

Adam Kleczkowski
Ciara Dangerfield
Christopher Gilligan
Nicholas Hanley
John Healey
Steven Hendry
Morag McPherson

UNIVERSITY OF STIRLING
UNIVERSITY OF CAMBRIDGE
PRIFYSGOL BANGOR UNIVERSITY
Forestry Commission

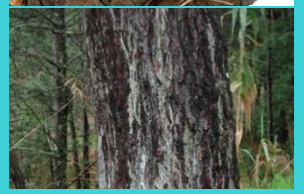
PROTREE

Promoting resilience of UK tree species to novel pests and pathogens: *ecological and evolutionary solutions*

Using Scots pine as a case study

Assess genetic variation in resistance to 3 key threat species:

- Dothistroma Needle Blight (*Present, widespread*)
- Pinetree Lappet moth (*Present, localised*)
- Pine pitch canker (*Not present, potential*)



Identify / test management strategies & communicate results

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

Contact: Stephen Cavers, scav@ceh.ac.uk

NERC SCIENCE OF THE ENVIRONMENT

3. Public appreciation of science

Respect public concerns & explain science honestly

1. Assessing expert risk awareness & management
2. Understanding public risk concern & behaviour
3. Analysing traditional & social media coverage

UNPICK

Understanding public risk and tree health

Lessons for policymakers and risk managers through detailed case studies of the nature and extent of public risk concern

www.imperial.ac.uk/unpick

Contact: Clive Potter – c.potter@imperial.ac.uk

Imperial College London

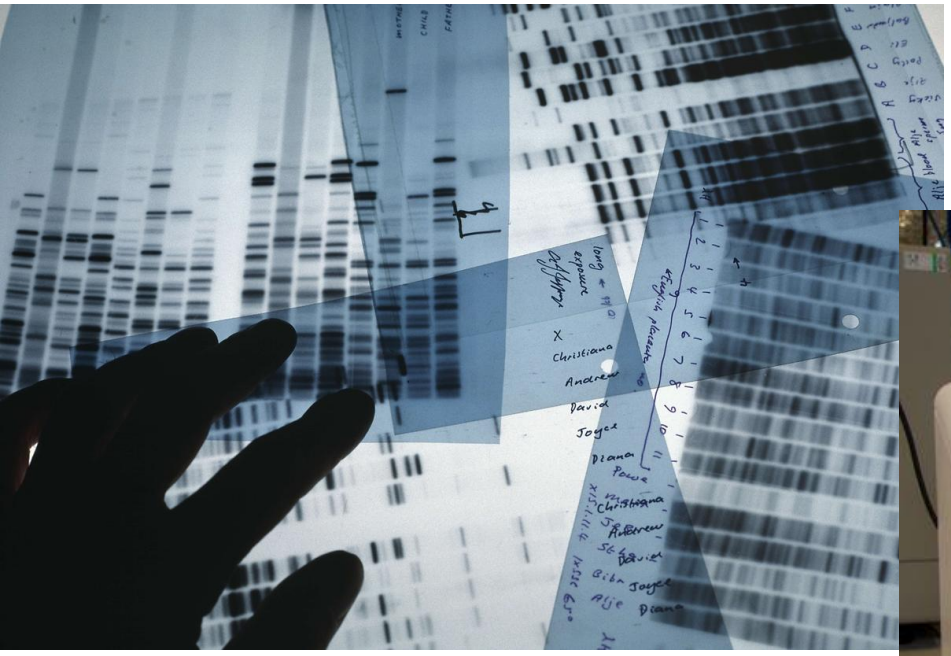
University of Bath

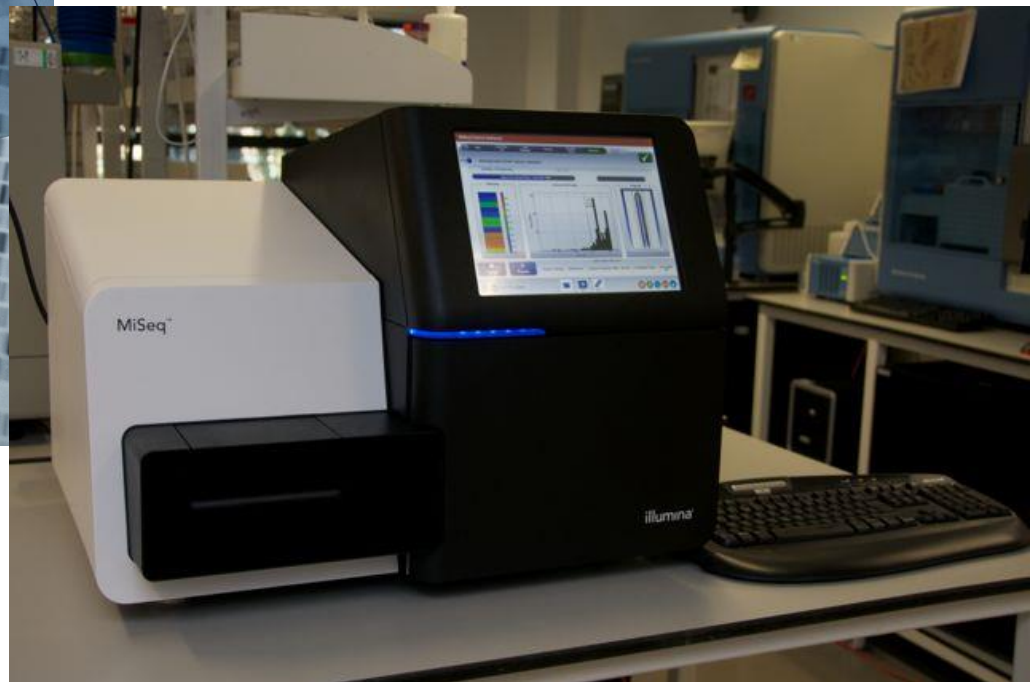
Forest Research

BBSRC bioscience for the future

4. Genomics

- Vastly accelerating our ability to ask significant biological questions





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Identifying genomic resources against pests and pathogens in tree genera: a case study in *Fraxinus*

Queen Mary University of London

Dr Richard Buggs & Prof Steve Rossiter: Genome sequencing and phylogenomics of whole ash genus

Forest Research

Dr Steve Lee: Genus-wise screening of susceptibility to ash dieback

FOREST SERVICE US DEPARTMENT OF AGRICULTURE

Dr Jennifer Koch: Screening of species' susceptibility to emerald ash borer

UNIVERSITY OF OXFORD

Dr Paul Jepson: Public opinion on genetic solutions to tree health issues

5. We need to understand biology of pathogens & ecology of disease

Biological Control of Insect Pests that Threaten Tree Health (BIPESCO)

Entomopathogenic fungi (EPF) and **botanicals** to control insect pests in forestry

Coordinator: Professor Tariq M. Butt, Dept. Biosciences, Swansea University

Targets: Asian longhorn beetle, Pine processionary moth, Pine weevil, Black vine weevil




Consortium: Swansea University (lead), Fera, Forest Research & industry

Industry: Manufacturers of EPF, botanicals & monitoring tools + nurseries & forestry groups − *Lisk & Jones Consultants, Sentomol, Greenerpol, Fargro, UPM, Maelor Forest Nurseries, Bord na Mona, MycoSolutions*

Population structure and natural selection in the ash dieback fungus

John Innes Centre

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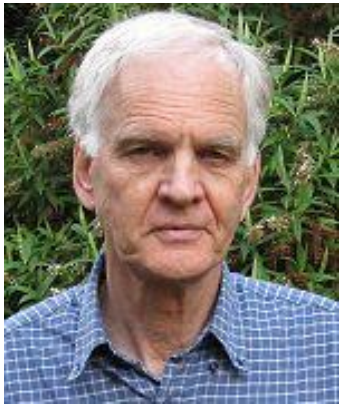
Forest Research

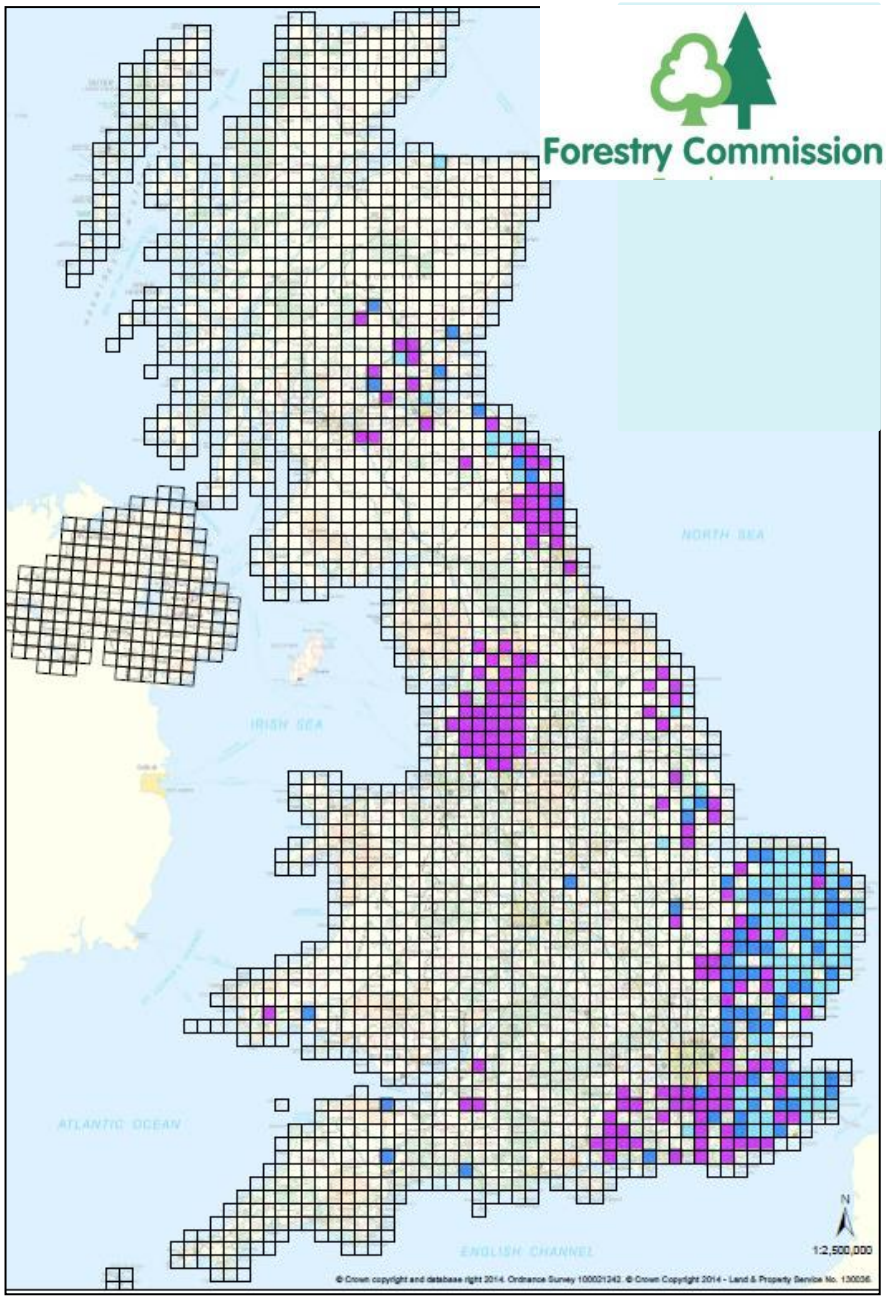
Elizabeth Orton

Anuradha Bansal + *Lorelei Bilham*

Joan Webber



Clive Brasier



Natural infections of *Hymenoscyphus fraxineus* in the UK

First UK observation in 2012 but probably present since 1990's

2012
2013
2014

Damage caused by ash dieback

The NORNEX Research Consortium

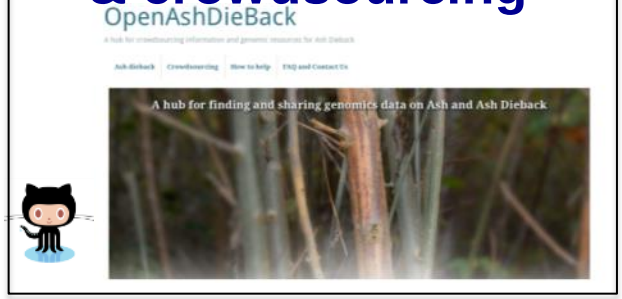
John Innes Centre
TGAC The Genome Analysis Centre™
The Sainsbury Laboratory TSL
Edinburgh genomics
University of Exeter
The University of York
emr east malling research
Forest Research
fera
University of Copenhagen
skog+landskap Norwegian Forest and Landscape Institute

Funding: BBSRC and Defra

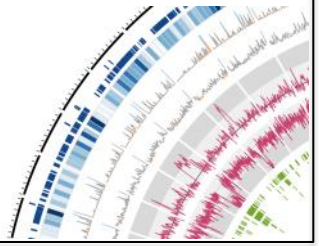
NERC

Queen Mary University of London

1. Open access & crowdsourcing



2. Fungal genomics & pathology



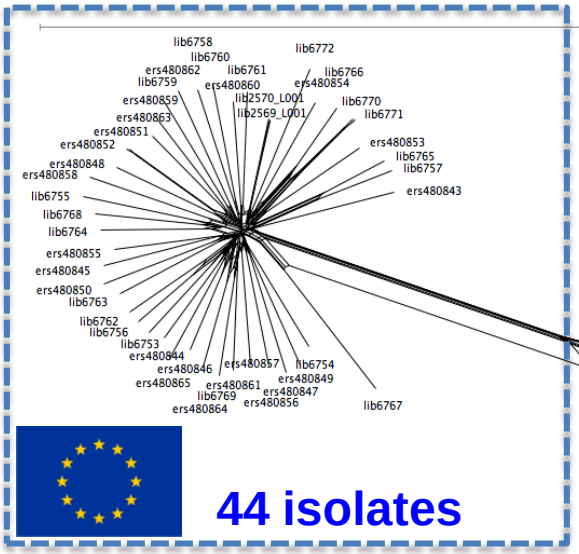
3. Tools to select tolerant trees

Building 21st century tools for a 21st century disease

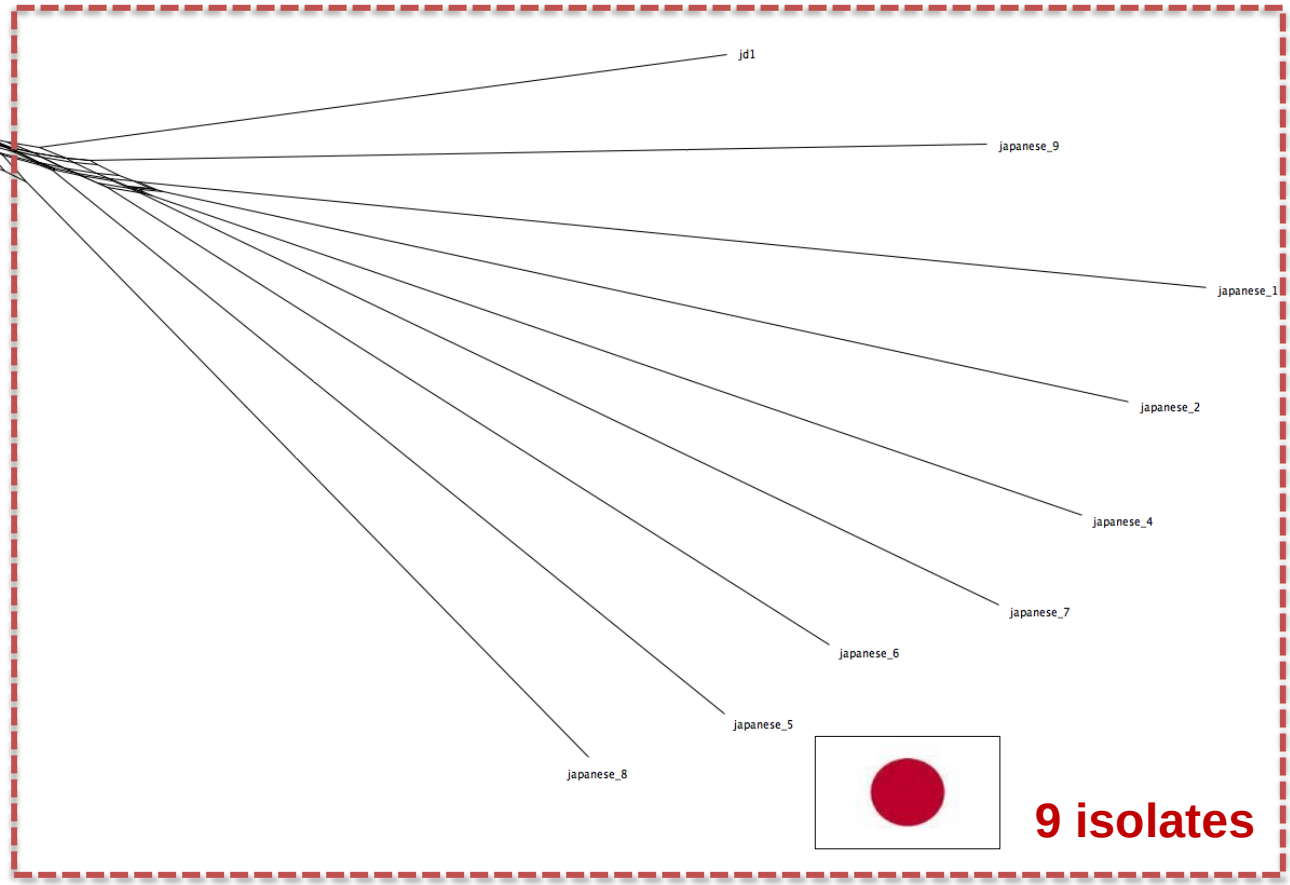
Hymenoscyphus fraxineus genomics

NORNEX

- Rapid insights into pathogen spread from genomics
- Native species in Far East Asia
- Very high diversity in Japan but didn't originate there



44 isolates



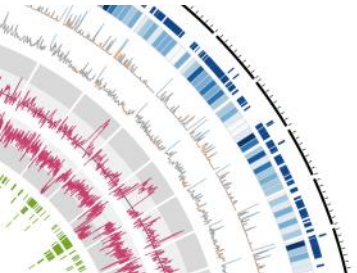
9 isolates

The Sainsbury Laboratory TSL

TGAC The Genome Analysis Centre™

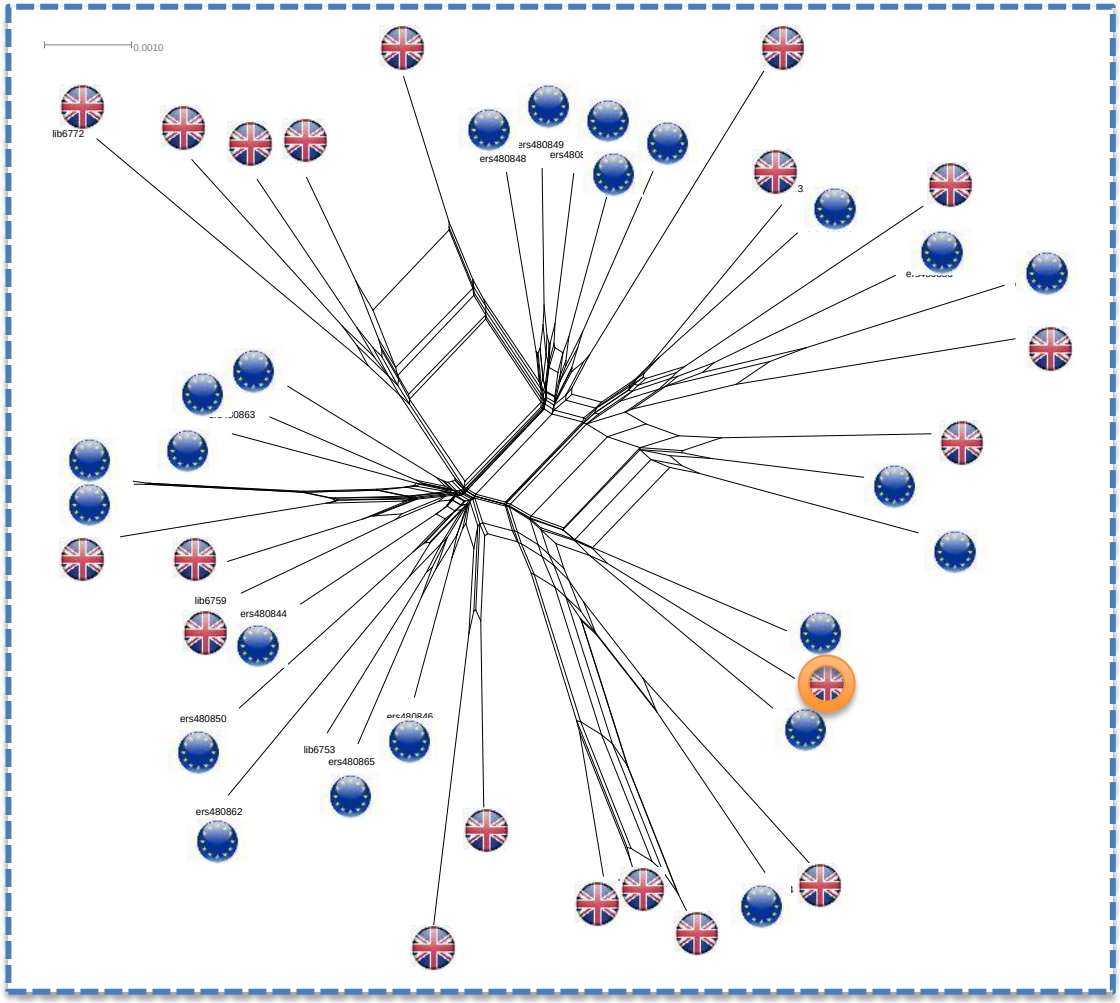
Edinburgh genomics

Mark McMullan



Hymenoscyphus fraxineus
European and UK genomes

NORNEX



TheSainsburyLaboratory TSL

TGAC The Genome Analysis Centre™

Edinburgh genomics

- Data on genetics of fungus show that it has moved between the UK and Europe frequently and in large numbers

Aim of JIC / FR ash dieback project

- How well & how quickly will UK ashwoods recover from the dieback epidemic?

Attenuated: myxomatosis

Severe & destructive: D.E.D.

Genetic structure of *Hymenoscyphus fraxineus* populations in UK

- Within woods & within infected trees

Diversity in dieback fungus: Vegetative compatibility defines individuals – very high diversity in UK

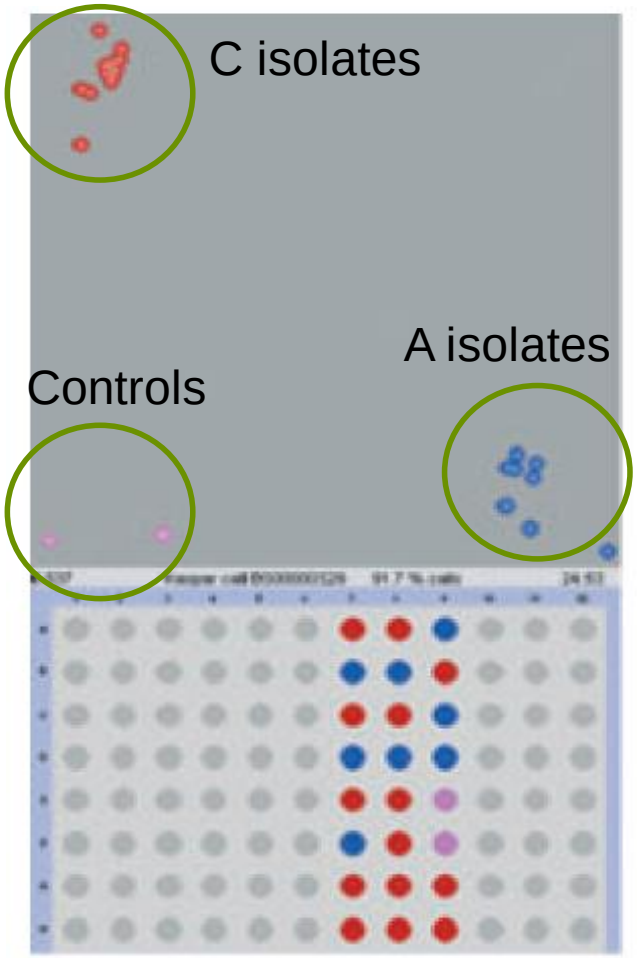
Diversity in dieback fungus: Genetic variation between fungal isolates

Kompetitive Allele Specific PCR (KASPar)
Developed by K-Bioscience

Tests variation in single bases of DNA
Using genome sequences from Nornex

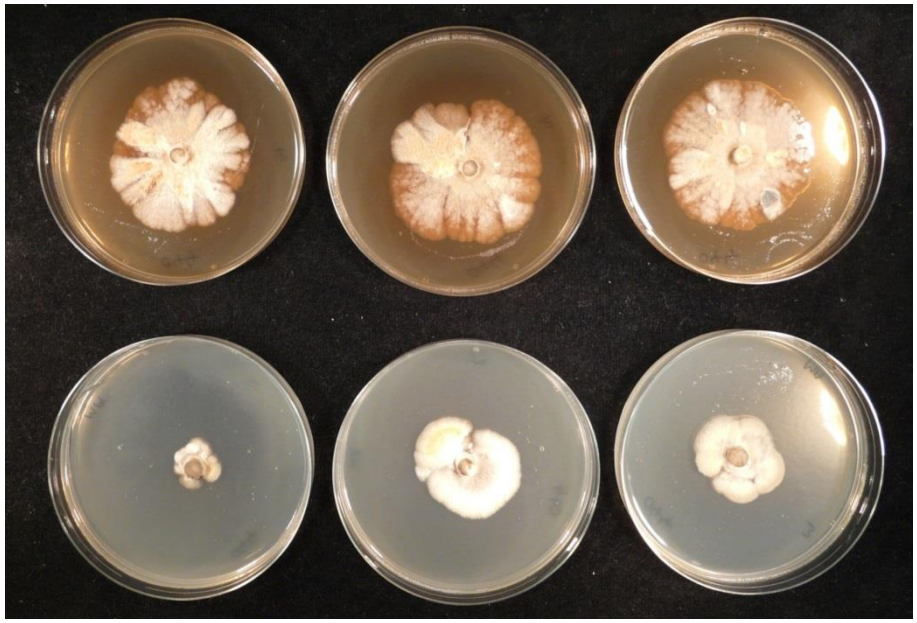
```
Isolate 1  CTGTAGGCATGTCCATGACTGAA
Isolate 2  CTGTAGGCATGTCCATGACTGAA
Isolate 3  CTGTAGGCATGTACATGACTGAA
Isolate 4  CTGTAGGCATGTCCATGACTGAA
```

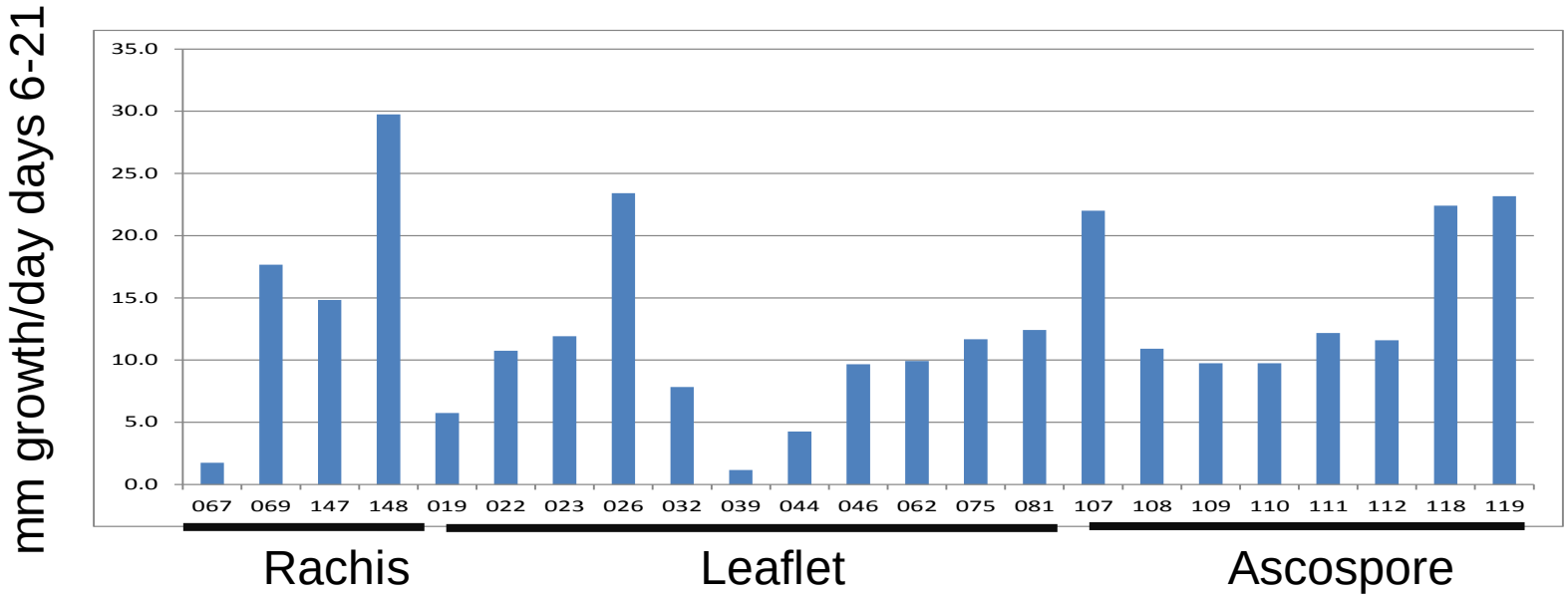
High diversity whether trees grown from diseased planting stock or infected by wind-blown spores from continent



Trade-offs of pathogenicity

- Main predictor of a mild outcome of epidemic
- Isolates with range of growth rates on Ash Leaf Agar
- Will test relationship to wide range of other traits





Relationship to *Hymenoscyphus albidus*

- Native non-pathogenic fungus
- Closely related to *H. fraxineus*
- Genetic & biological diversity
- How do *H. fraxineus* and *H. albidus* interact?
- Will it help us to predict long-term outcome of ash dieback?

Ash dieback in the long term: natural selection in action

- Massive production of fruiting bodies & wind-borne spores
- If seed from resistant trees is allowed to spread, ash may re-establish as a major broadleaf tree
- (if there are costs of pathogenicity in the fungus)

6. We need a long-term commitment to rebuilding expertise in forest pathology in UK

Acknowledgements

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