

Expansion et évolution de la chalarose du frêne

JP Soularue, A Gross, G St-Jean, J Faivre d'Arcier, L Dubois, J Dudit,
C Bécans, J Carbonel-Rabocelli, C Clavé, W Trebier et C Robin

Journée Santé des forêts, Cestas, 10/12/21

INRAE

biogeco

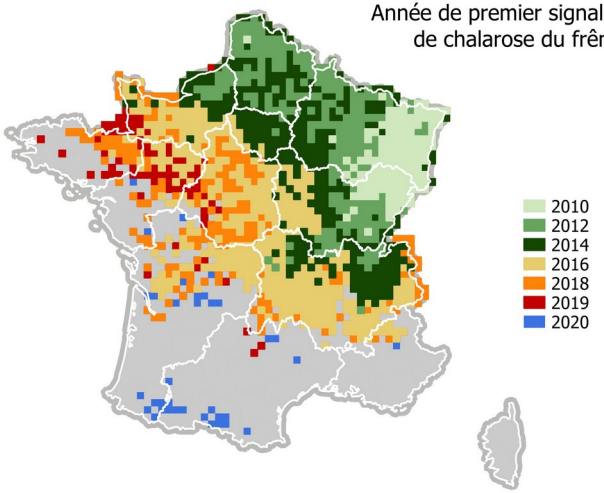
La chalarose, une menace pour le frêne











Crédit : Département Santé des Forêts

1er signalement en Haute-Saône en 2008

Seulement 1 à 5 % des frênes résistants

Une crise sanitaire majeure
pour les écosystèmes forestiers au sein
desquels le frêne est dominant

Le frêne



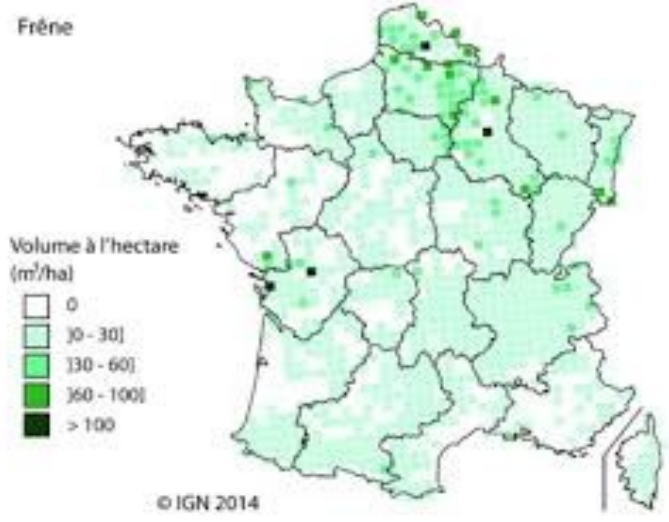
- Espèce pionnière à croissance rapide

  Contribue à l'équilibre hydrique des peuplements, produit une litière utile, ralentit les incendies, utile à la survie de nombreuses espèces

- 93 millions de m^3 sur pied sur 700 000 hectares (IGN)

  4ème essence feuillue de production de bois

  → ornement, ameublement



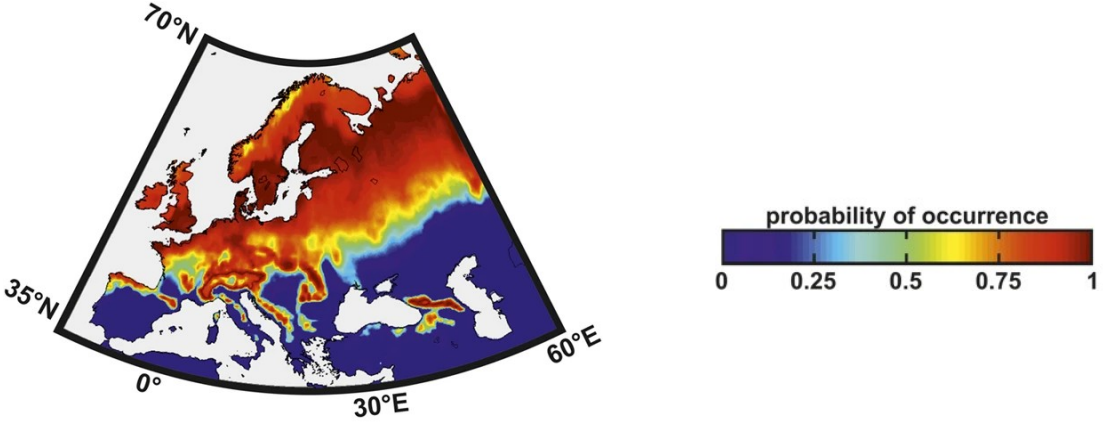
Objectifs

Anticiper, et préconiser des actions adaptées, nécessitent une bonne compréhension des processus qui soutiennent le développement de cette épidémie (voir projet Chalfrax CNPF, DSF, INRAe Nancy, Orléans…)

→ Le potentiel *évolutif* des pathogènes forestiers est à prendre en considération (Desprez-Loustau et al. 2016), particulièrement dans un contexte de changements climatiques

→ La rapide propagation de la chalarose du frêne est-elle soutenue par un processus d'*évolution* de son agent causal ?

Goberville et al. (2016) : probabilité d'occurrence de la maladie en fonction du climat



Objectifs

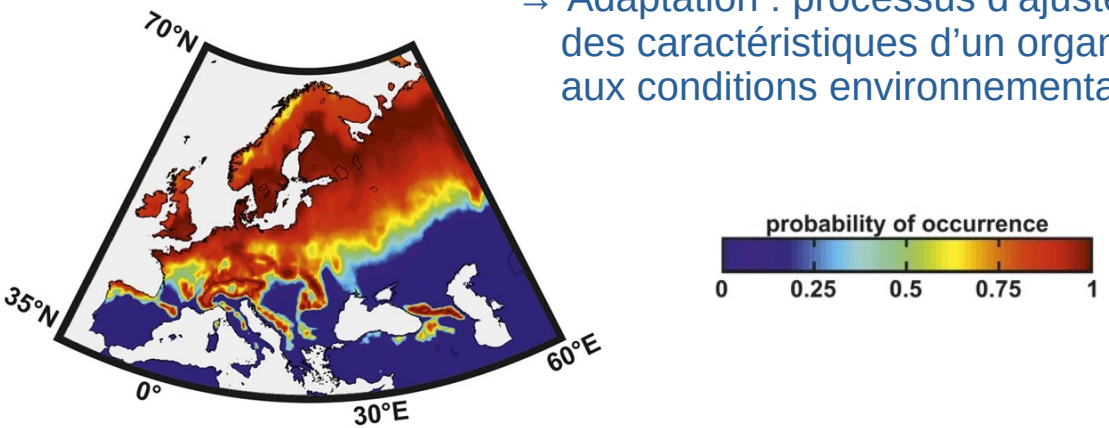
Anticiper, et préconiser des actions adaptées, nécessitent une bonne compréhension des processus qui soutiennent le développement de cette épidémie (voir projet Chalfrax CNPF, DSF, INRAe Nancy, Orléans…)

→ Le potentiel *évolutif* des pathogènes forestiers est à prendre en considération (Desprez-Loustau et al. 2016), particulièrement dans un contexte de changements climatiques

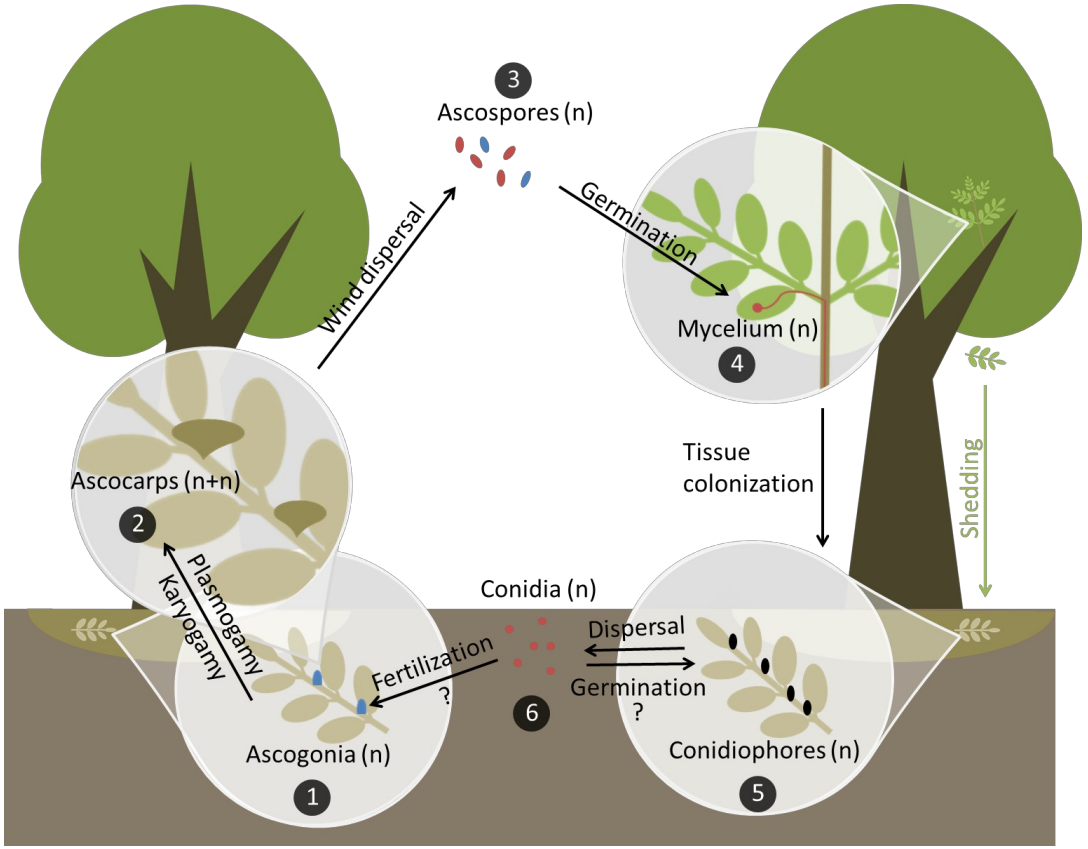
→ La rapide propagation de la chalarose du frêne est-elle soutenue par un processus d'*évolution* de son agent causal ?

→ Adaptation : processus d'ajustement des caractéristiques d'un organisme aux conditions environnementales

Goberville et al. (2016) : probabilité d'occurrence de la maladie en fonction du climat



L'agent causal est *Hymenoscyphus fraxineus*



(Issu du rapport de Master d'Astrid Koehl (2018))

Nom forme asexuée :
Chalara fraxinea

Champignon hétérothallique haploïde

Originaire d'Asie

Introduit en Pologne dans les années 90

Dispersion aérienne : infections par ascospores

Propagation intra-hôte clonale

Une épidémie en cours de développement, à l'échelle du continent

Ash dieback in Poland – history of the phenomenon and possibilities of its limitation

W. Gil*[1], T. Kowalski[2], W. Kraj[2], T. Zachara[1], J. Łukaszewicz[1], R. Paluch[3], J. A. Nowakowska[4], T. Oszako[5]

[1] Dept. of Silviculture and Forest Tree Genetics, Forest Research Institute, Sękocin Stary, Braci Leśnej 3, PL05090 Raszyn, Poland, [2] Department of Forest Pathology, Mycology and Tree Physiology, Agricultural University in Cracow, Al. 29-Listopada 46, 31-425 Cracow, Poland, [3]Department of Natural Forests, Forest Research Institute, Park Dyrekcyjny 6, PL17230 Białowieża, Poland, [4]Molecular Biology Laboratory, Forest Research Institute, Sękocin Stary, Braci Leśnej 3, PL05090 Raszyn, Poland, [5]Dept. of Forest Protection, Forest Research Institute, Sękocin Stary, Braci Leśnej 3, PL05090 Raszyn, Poland
**corresponding author: GilW@ibles.waw.pl*

Abstract
The phenomenon of dying stands of ash was observed in Poland since 1993. The aim of the study was to assess the health condition of ash stands in the State Forests and to develop silviculture methods for subsequent phases of forest growth in stands with a significant share of ash, in order to minimize the negative consequences of ash dieback and to increase the durability and sustainability of these stands. In order to assess its scale, in 2004, we sent a questionnaire to all forest districts of the State Forests, operating on the surface of approx. 7.6 million hectares equaled 83% of the forest area. The article presents data on the extent and impact of ash dieback in Poland, genetic structure of Polish ash populations revealed by the DNA marker studies, genetic variability of Hymenoscyphus fraxineus in Poland and recommends silvicultural options to mitigate impact of the disease.

Introduction

Ash stands in Poland (with prevailing ash) occurred at the beginning of the twenty-first century, on an area of approximately 28.5 thousand ha - less than 1% of the total forest area of Poland (9.1 million ha) (Gil *et al.* 2006). On the most eutrophic habitats and wetland, where ash can be a dominant species or provide significant admixture its importance is the highest. The most common are the habitats of humid forests (more than 9.5 thousand ha), fresh forest (5,5 thousand ha), alder-ash stands (5.2 thousand ha) and riparian forests (2.3 thousand ha). The largest area of forest stands of ash appeared in Polish regions characterized by mild sub-Atlantic climate, especially in the south - western part of the country.

In Poland the growth of ash trees was not hampered by serious fungal or bacterial diseases (Grzywacz 1995). However, this situation fundamentally changed in the late twentieth century. In 1992, there were first signs of severe dieback of ash in the north-eastern Poland (Stocki 2001). In the following years this process has spread to other areas of the country (Kowalski 2001, Przybył 2002), covering an area of over 10 000 hectares (Gil *et al.*



EUFORGEN : frêne commun en Europe

Une épidémie en cours de développement, à l'échelle du continent

Ash dieback in Poland – history of the phenomenon and possibilities of its limitation

Extended Abstract

Ash dieback associated with *Hymenoscyphus pseudoalbidus* in forest nurseries in Austria

Thomas Kirisits*, Peter Kritsch, Katharina Kräutler, Michaela Matlakova and Erhard Halmschlager

Institute of Forest Entomology, Forest Pathology and Forest Protection (IFFF), Department of Forest and Soil Sciences, University of Natural Resources and Life Sciences, Vienna (BOKU), Hasenauerstraße 38, A-1190 Vienna, Austria.

Accepted 30 November, 2011

Dieback of *Fraxinus excelsior, Fraxinus angustifolia* and other *Fraxinus* species is an emerging infectious disease caused by the ascomycete fungus *Hymenoscyphus pseudoalbidus* (anamorph *Chalara fraxinea*). Investigations in five forest nurseries in Austria from 2008 to 2011 showed that ash dieback is a common and important disease of nursery seedlings. *H. pseudoalbidus* was consistently isolated at high frequencies from symptomatic *F. excelsior* and *F. angustifolia* seedlings, confirming that this fungus is associated with ash dieback. Symptom observations on potted seedlings revealed progression of the disease outside the vegetation period and thus a long incubation period in the disease cycle of ash dieback. Apothecia of *H. pseudoalbidus* were occasionally observed on dead ligneous parts of common ash, including stems of nursery seedlings. This suggests that a low portion of diseased seedlings can initiate new infections, which may be important for moving the pathogen to new areas. Based on our observations and studies in forest nurseries and the present knowledge on the disease cycle of ash dieback, recommendations for disease management in tree nurseries and concerning artificial regeneration are presented.

Key words: *Chalara fraxinea*, *Fraxinus excelsior*, *Fraxinus angustifolia*, emerging forest disease, disease management.

INTRODUCTION

During the last two decades, ash dieback caused by the ascomycete fungus *Hymenoscyphus pseudoalbidus* sm (Husson et al., 2011; Queloz et al., 2011; Timmermann et al., 2011). Trees of all ages, in the forest



EUFORGEN : frêne commun en Europe

Une épidémie en cours de développement, à l'échelle du continent

Ash dieback in Poland – history of the phenomenon and possibilities of its limitation

Extended Abstract

Ash dieback associated with *Hymenoscyphus pseudoalbidus* in forest nurseries in Austria

Contents lists available at ScienceDirect

Biological Conservation

journal homepage: www.elsevier.com/locate/biocon

Review

Ash dieback in the UK: A review of the ecological and conservation implications and potential management options

R.J. Mitchell [a,*], J.K. Beaton [a], P.E. Bellamy [b], A. Broome [c], J. Chetcuti [c], S. Eaton [d], C.J. Ellis [d], A. Gimona [a], R. Harmer [e], A.J. Hester [a], R.L. Hewison [a], N.G. Hodgetts [f], G.R. Iason [a], G. Kerr [e], N.A. Littlewood [a], S. Newey [a], J.M. Potts [g], G. Pozsgai [a], D. Ray [c], D.A. Sim [a], J.A. Stockan [a], A.F.S. Taylor [a], S. Woodward [h]

[a] The James Hutton Institute, Craigiebuckler, Aberdeen AB15 8QH, United Kingdom
[b] The Royal Society for the Protection of Birds, The Lodge, Sandy, Bedfordshire SG19 2DL, United Kingdom
[c] Forest Research, Northern Research Station, Roslin, Midlothian EH25 9SY, United Kingdom
[d] Royal Botanic Garden Edinburgh, 20A Inverleith Row, Edinburgh EH3 5LR, United Kingdom
[e] Forest Research, Alice Holt Lodge, Farnham, Surrey GU10 4LH, United Kingdom
[f] Bryophyte Consultant, Cuillin Views, 15 Earlish, Portree, Isle of Skye IV51 9XL, United Kingdom
[g] Biomathematics and Statistics Scotland, Craigiebuckler, Aberdeen AB15 8QH, United Kingdom
[h] University of Aberdeen, Institute of Biological and Environmental Sciences, Department of Plant and Soil Sciences, Cruickshank Building, St. Machar Drive, Aberdeen AB24 3UU, United Kingdom

ARTICLE INFO

Article history:
Received 2 December 2013
Received in revised form 24 March 2014
Accepted 23 April 2014
Available online 20 May 2014

ABSTRACT

The death of native trees caused by non-native pathogens is a global problem. An assessment of the potential ecological and conservation impacts of any tree disease should identify: (1) ecosystem functions associated with the tree species; (2) which species use the tree and how; (3) the suitability of alternative tree species to replace the threatened tree species; and (4) potential management options to mitigate or reduce the impact of the disease.

We assess the potential ecological impact of *Hymenoscyphus pseudoalbidus* (ash dieback) on *Fraxinus*



EUFORGEN : frêne commun en Europe

Une épidémie en cours de développement, à l'échelle du continent

Ash dieback in Poland – history of the phenomenon and possibilities of its limitation

Extended Abstract

Ash dieback associated with *Hymenoscyphus pseudoalbidus* in forest nurseries in Austria

Contents lists available at ScienceDirect

Biological Conservation

journal homepage: www.elsevier.com/locate/biocon

Review

First Record of Ash Dieback Caused by *Hymenoscyphus fraxineus* on *Fraxinus excelsior* in the Apennines (Tuscany, Italy)

N. Luchi, L. Ghelardini, A. Santini, D. Migliorini, and P. Capretti

Affiliations

Published Online: 7 Jan 2016 | https://doi.org/10.1094/PDIS-09-15-0975-PDN

e-Xtra TOOLS

Hymenoscyphus fraxineus (T. Kowalski) Baral, Queloz & Hosoya represents a relevant fungal pathogen in Europe causing a wide range of symptoms on common ash trees (*Fraxinus excelsior*) (Kowalski 2006). The infection consists of necrosis on leaflets and rachises, twigs dieback, and finally the death of the tree (Kräutler and Kirisits 2012). In Italy, the disease has been reported on *F. excelsior* since 2010 in the



EUFORGEN : frêne commun en Europe

Une épidémie en cours de développement, à l'échelle du continent

Ash dieback in Poland – history of the phenomenon and possibilities of its limitation

Extended Abstract

Ash dieback associated with *Hymenoscyphus pseudoalbidus* in forest nurseries in Austria

Contents lists available at ScienceDirect

Biological Conservation

journal homepage: www.elsevier.com/locate/biocon

Review

First Record of Ash Dieback Caused by *Hymenoscyphus fraxineus* on *Fraxinus excelsior* in the Apennines (Tuscany, Italy)

forests

MDPI

Article

Development of Ash Dieback in South-Eastern Germany and the Increasing Occurrence of Secondary Pathogens

Heike D. Lenz *, Bernadett Bartha, Ludwig Straßer and Hannes Lemme

Bavarian State Institute of Forestry, Hans-Carl-von-Carlowitz-Platz 1, 85354 Freising, Germany; bartha.berni@gmail.com (B.B.); ludwig.strasser@lwf.bayern.de (L.S.); hannes.lemme@lwf.bayern.de (H.L.)
* Correspondence: heike.lenz@lwf.bayern.de; Tel.: +49-8161-71-4929; Fax: +49-08161-71-4971



UFORGEN : frêne commun en Europe

Une épidémie en cours de développement, à l'échelle du continent

Ash dieback in Poland – history of the phenomenon and possibilities of its limitation

Extended Abstract

Ash dieback associated with *Hymenoscyphus pseudoalbidus* in forest nurseries in Austria

Contents lists available at ScienceDirect

Biological Conservation

journal homepage: www.elsevier.com/locate/biocon

Review

First Record of Ash Dieback Caused by *Hymenoscyphus fraxineus* on *Fraxinus excelsior* in the Apennines (Tuscany, Italy)

forests

Article

Develo… Germar… Second…

Heike D. Len…

Bavarian State…



MDPI

WILEY Forest Pathology

ORIGINAL ARTICLE

Do higher summer temperatures restrict the dissemination of *Hymenoscyphus fraxineus* in France?

M. Grosdidier[1,2] | R. Ioos[2] | B. Marçais[1]

…urope

Une épidémie en cours de développement, à l'échelle du continent

Ash dieback in Poland – history of the phenomenon and possibilities of its limitation

Extended Abstract

Ash dieback associated with *Hymenoscyphus pseudoalbidus* in forest nurseries in Austria

Contents lists available at ScienceDirect

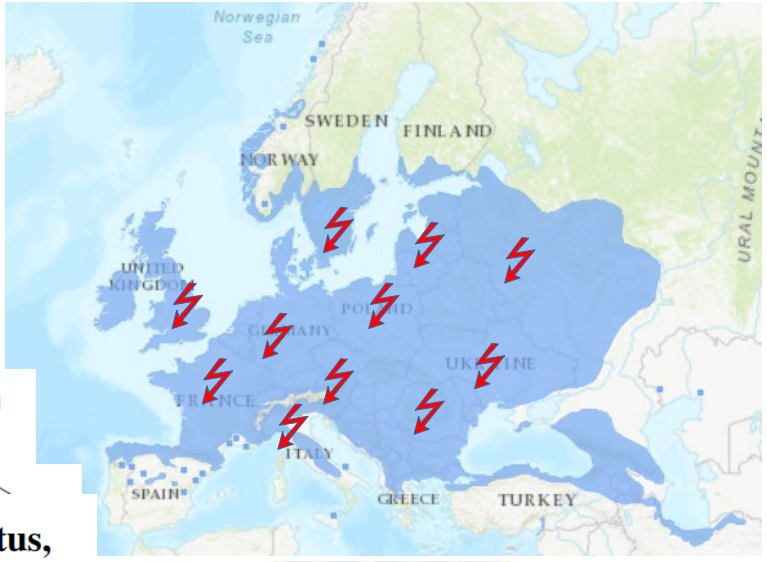
Biological Conservation

journal homepage: www.elsevier.com/locate/biocon

Review

First Record of Ash Dieback Caused by *Hymenoscyphus fraxineus* on *Fraxinus excelsior* in the Apennines (Tuscany, Italy)

N. Luchi, L



WILEY Forest Pathology

Ash and ash dieback in Sweden: a review of disease history, current status, pathogen and host dynamics, host tolerance and management options in forests and landscapes

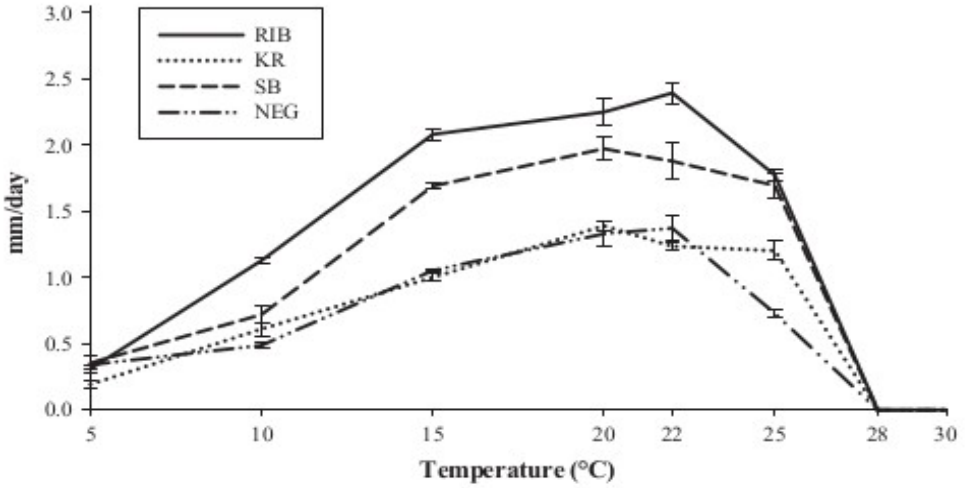
M. CLEARY[1]*, D. NGUYEN[2], L. G. STENER[3], J. STENLID[2], J. P. SKOVSGAARD[1]

[1] *Southern Swedish Forest Research Center, Swedish University of Agricultural Sciences, Sundsvägen 3, Alnarp, Sweden,* [2] *Department of Forest Mycology and Plant Pathology, Swedish University of Agricultural Sciences, Almas allé 5, Uppsala, Sweden,* [3] *Skogforsk, Ekebo, Sweden.*
**corresponding author: Michelle.Cleary@slu.se*

:urope

the dissemination of

Quel tolérance thermique chez *H. fraxineus* ?





Kowalski et al. (2010), puis, Hauptman et al. (2013), i*n vitro*, pour des populations (individu = isolat) polonaises et slovènes :

→ optimum de croissance de 20-22°C,
→ croissance possible aux température très basses
→ pas de croissance au dessus de 28 °C

Réalisé sur des populations proches de l'aire d'introduction
→ Un pathogène qui « aime le froid »
→ Les populations plus récemment établies présentent-elles un profil de tolérance thermique différent ?

Echantillonnage de rachis infectés





En 2020 ★ :

Lituanie

Danemark

Suisse

Italie

France-Aveyron

Population ancienne (nord)



Population récente (sud)





Etude *in vitro* : les populations européennes d'*H. fraxineus* présentent-elles des sensibilités à la température différentes ?

Rachis préparés



Préparation milieu



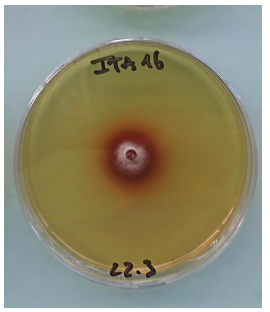
Prélèvement tissus infectés



Mise en culture (22 °C)



Croissance 2 semaines



Etape I :
Isolement du pathogène

Préparation milieu



Repiquages

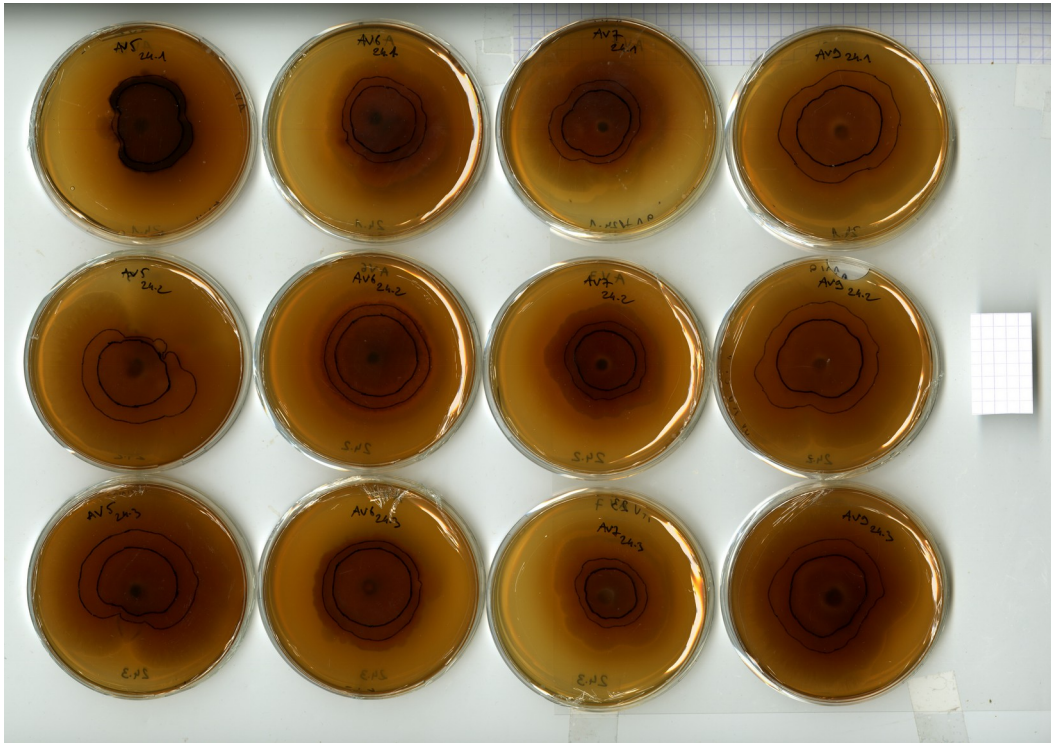


Mise en culture 22, 24, 26, 27 °C



Etape II :
Repiquages et culture en enceintes climatiques
5 pops x 15 isolats x 4 T°
x 3 répétitions = 900 boîtes

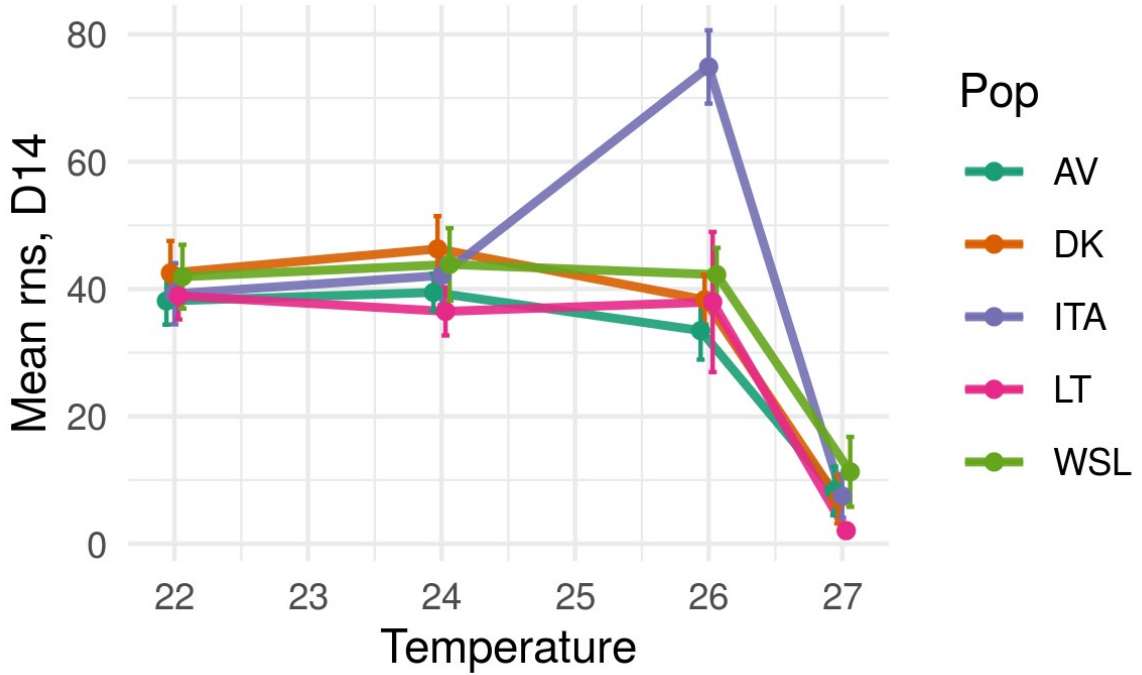
Etude *in vitro* : les populations européennes d'*H. fraxineus* présentent-elles des sensibilités à la température différentes ?



ImageJ
Image Processing and Analysis in Java

Etape III :
Mesure
diamètres
moyens
mycellium
à J7 et J14

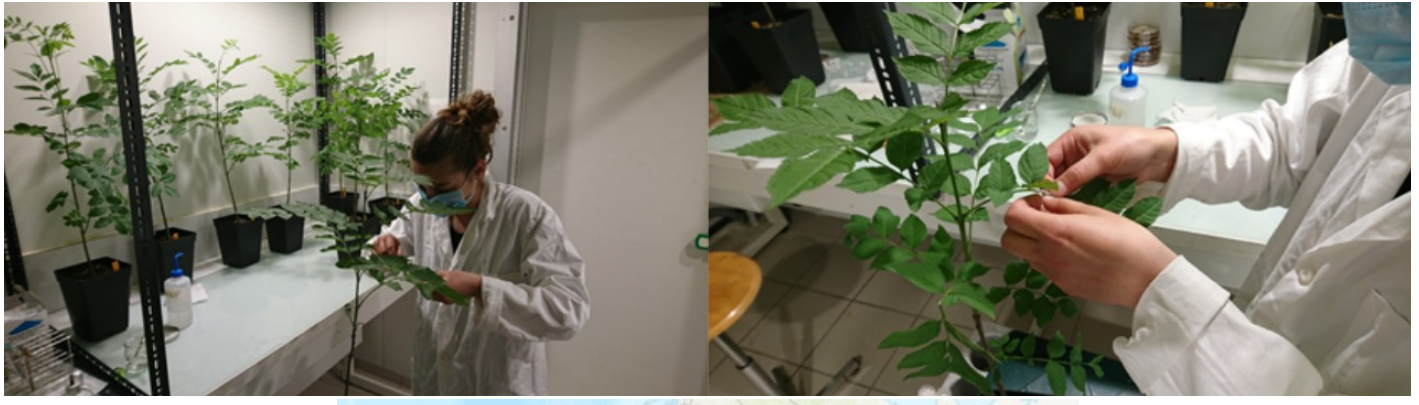
Croissance moyenne des populations d'*H. fraxineus* en fonction de la température

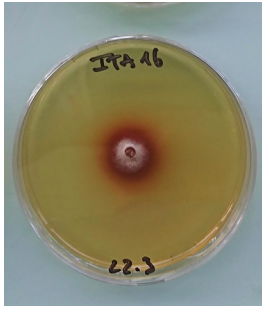


→ La population italienne présente un optimum de croissance clair à 26°C
→ Pas de différentiation entre les autres populations

Etude *in planta* (en cours) : les populations d'*H. fraxineus* diffèrent-elles par leur agressivité ?

Agressivité → capacité d'un pathogène à occasionner des dégâts à son hôte

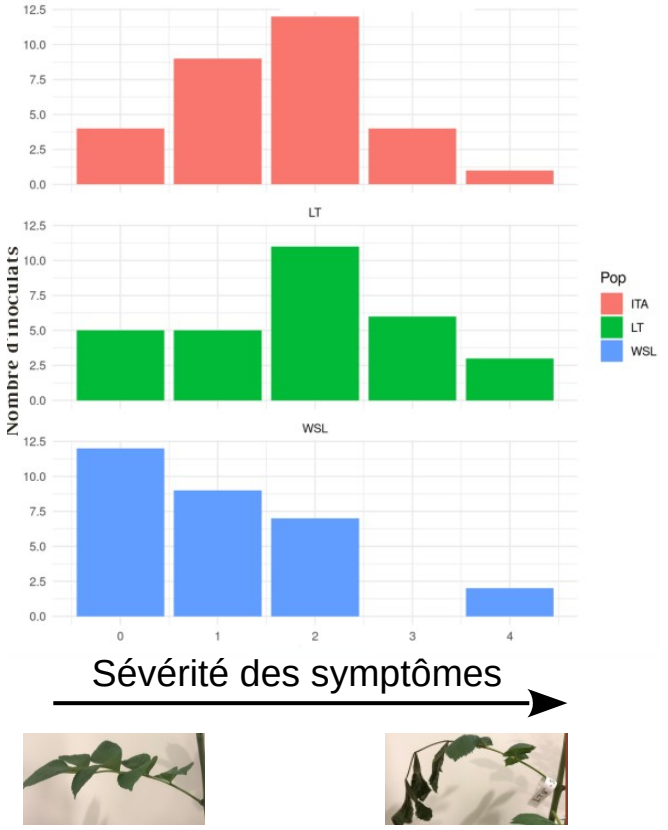


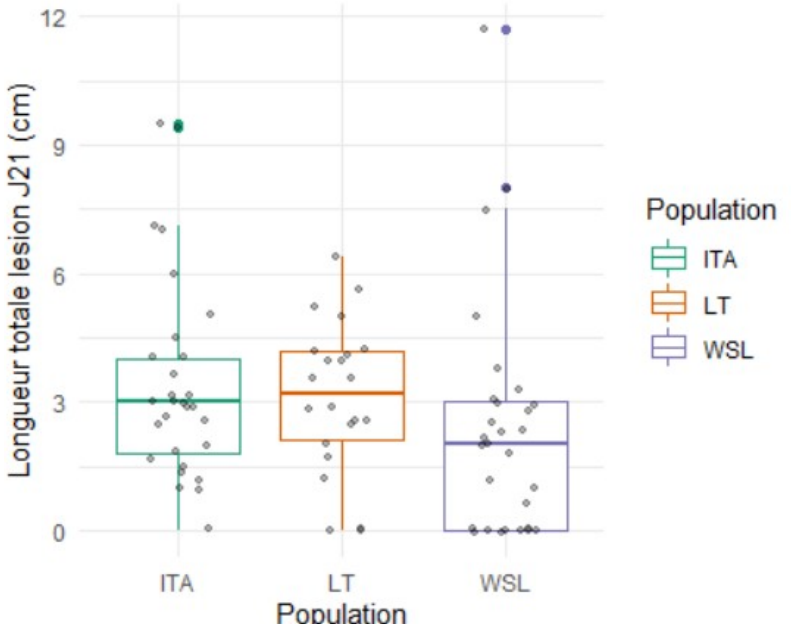




Méthode de Orton et al. (2019)

Etude *in planta* (en cours) : les populations d'*H. fraxineus* diffèrent-elles par leur agressivité ?

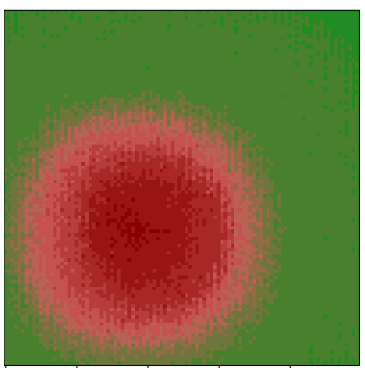


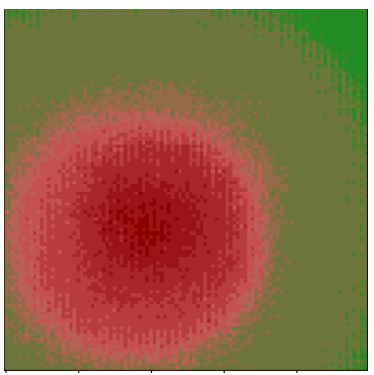


Résultat préliminaire :
→ A priori peu de différences d'agressivité entre populations

Synthèse

- La propagation de l'épidémie en Italie semble être soutenue par une adaptation d'*H. fraxineus* aux températures élevées en Italie
- Nos premières évaluations d'agressivité de trois populations d'*H. fraxineus* ne suggèrent pas de différences flagrantes d'agressivité entre ces populations, à confirmer
- Ces résultats sont importants car ils peuvent permettre d'affiner les prédictions de propagation de la maladie, de sa persistance, et du risque au sein des peuplements français et européens. D'autres facteurs, tel que la densité de peuplement (ex : projet Chalfrax), sont à considérer
- Ils peuvent en particulier nous aider à anticiper les dynamiques d'évolution d'*H. fraxineus* à venir, ex de prédiction qualitative d'un de nos modèles :





Influence de *l'héritabilité* de la pathogénicité sur la mortalité générée par *H. fraxineus* à la suite de l'émergence de la maladie dans un paysage initialement composé de 46 % d'arbres résistants et 54 % d'arbres sensibles

Merci



Département Santé des Forêts

Dominique Piou (DSF Cestas)

Luisa Ghelardini (UNIFI Florence)

Benoît Marçais (INRAE Nancy)

Vaidotas Lygis (NRC Vilnius)

Lene Rostgaard Nielsen (Université de Copenhague)

Martine Martin-Clotté (INRAE Cestas)

Céline Lalanne (INRAE Cestas)

Alice Bedani (INRAE Cestas)

Kattarina Budde (Université de Göttingen)

Myriam Heurtz (INRAE Cestas)

Thierry Bélouard (DSF Cestas)

Xavier Capdevielle (INRAE Cestas)