Adaptation patterns to temperature in the potato late blight pathogen

*Phytophthora infestans*

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Introduction
Crop pests and pathogens

- Threat for global food security
  - Loss of 15% of crop production (Flood, 2010)

- Life cycle highly dependent on climatic variables:
  - Rainfall – Insolation – Temperature

- Global warming
  - Projections provide an increase of average temperatures
    - 1.5 - 2°C by 2100
  - Increased interest in the effect of climate change on the ecology and evolutionary potential of plant pathogens
    - Ex. Studies on temperature reaction norms

Published literature on CC & plant pathogens (Chakrabborty, 2013)

IPCC projections for global temperature (IPCC 2007)
Introduction

- Example of an experiment on thermal reaction norms of a plant pathogen

**Puccinia striiformis**

- Wheat yellow rust

- 17 isolates from two French areas (North and South)
- Tested at five temperatures (7-25°C)

Mboup *et al*., 2011

- Pattern of temperature-dependant local adaptation

- What do we know about *Phytophthora infestans*?

- Effects of temperature on different clonal lineages
  - **Brazil**: BR-1 & US-1 (*Maziero et al*., 2009)
  - **GB**: 6_A1, 13_A2, 2_A1, 8_A1... (*Cooke et al*., 2012)

- No experiment conducted to test the hypothesis of a local adaptation to temperature
Objectives of this study:

- Investigate the temperature reaction norms for three life history traits of *P. infestans* isolates
  - from geographically separated populations
    - Local adaptation?
  - from different clonal lineages (6_A1 vs 13_A2)

Introduction
Materials & Methods
Materials & Methods

- **Isolate origin**
  - 42 isolates sampled in 2013 in three geographical areas
  - genotyped with 17 SSR markers

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<th>Average temperatures (°C)</th>
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<tr>
<td>Annual</td>
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<td>13.6</td>
<td>11.5</td>
<td>25.2</td>
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**Climate-data.org**
Materials & Methods

- **Biological characterization of isolates**

1. **Inoculation**
   - detached leaflets of the susceptible potato cv Bintje
   - 6 leaflets per isolate

2. **Incubation**
   - 4 temperatures (10°C, 14°C, 18°C & 24°C)

3. **Measurement of life history traits**
   - Latent period (LP)
   - First sporangia
   - Lesion size (LS)
   - Sporangia production (SP)
Results

1. Differences between geographical areas
Results

A local adaptation pattern?

- Northern isolates slightly better at 10°C and less well performing at 18°C & 24°C
- Conversely for Mediterranean isolates
- Western isolates slightly better performing at 14°C

Statistical analysis

- Linear mixed effects models (fixed factors: temperature & geographical origin; random factors) (R, package lme4)
- Effect of fixed factors: Wald test (R, package car)
- Post-hoc comparison with the Least Squares Means (R, package lsmeans)
Results

- Northern isolates have a longer latent period
  - Even at low temperatures (10°C & 14°C)

- Northern isolates cause smaller lesions
  - than Western isolates at low temperatures (10°C & 14°C)
  - than Western and Southern isolates at high temperatures (18°C & 24°C)
Results

2. Differences between clonal lineages
Results

- **Same latent periods for 13_A2 & 6_A1 isolates**
- **6_A1 isolates cause larger lesions at low temperatures**
- **6_A1 isolates produce more sporangia at all temperatures**

![Graphs showing latent period, lesion size, and sporangia production for different temperatures.](image-url)
Discussion
Discussion

- A local adaptation pattern detected for sporangia production
- No local adaptation patterns detected for the other traits
  - Northern isolates generally have long latent periods and low lesion growth rates
How to explain the relative low performances of the Northern isolates for latent period and the lesion size?

**“Fast” isolate**
- Short latent period
- High lesion growth rate

**“Slow” isolate**
- Long latent period
- Low lesion growth rate

Arrival on the host → Blight development → Co-infection possible → Oospore formation

If co-infection with a sexual partner

Co-infection not possible → No oospore formation
How to explain the relative low performances of the Northern isolates for latent period and the lesion size?

**“Fast” isolate**
- Short latent period
- High lesion growth rate

**“Slow” isolate**
- Long latent period
- Low lesion growth rate

**Low transmission rate**

**High transmission rate**

**In Northern Europe**
- Cold winters avoid the asexual survival of *P. infestans*
- If progeny have the pathogenic characteristics of their parents
- It could explain the selection of “slow” isolates in Northern Europe

**Arrival on the host**

**Blight development**

**Co-infection not possible**

**No oospore formation**

**If co-infection with a sexual partner**

**Oospore formation**
Discussion

- Differences observed in the temperature responses between clonal lineages

  - 6_A1 isolates better performing than 13_A2, in particular at low temperatures

    - Other traits could counter-balance these differences (e.g., sporangia size)?

Cf. Poster of Mabon et al.

- Given the differences between clonal lineages, a better way for detecting local adaptation patterns would be to compare isolates of the same clonal lineage from different geographical areas

  - In our dataset, no clonal lineage present in all three geographical areas

  - But 13_A2 isolates from Western Europe (n=8) and the Mediterranean basin (n=6)
Detection of a pattern of local adaptation to temperature for lesion size and sporangia production

- Western isolates better performing at low temperatures
- Southern isolates better than western isolates at high temperatures
- First report in *P. infestans*
Thank you to:

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