Adaptation patterns to temperature in the potato late blight pathogen *Phytophthora infestans*

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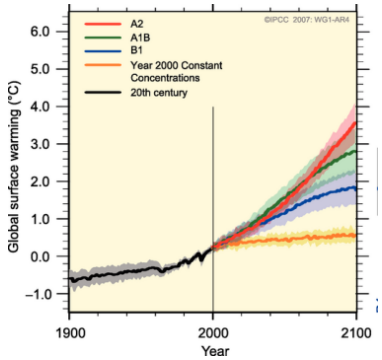
Introduction

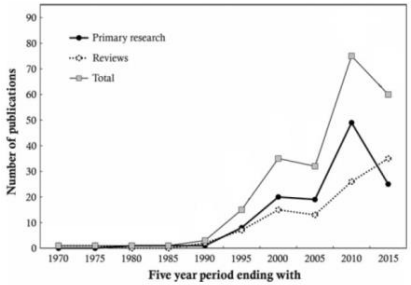
Introduction

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



IPCC projections for global temperature (IPCC 2007)



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

Introduction

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

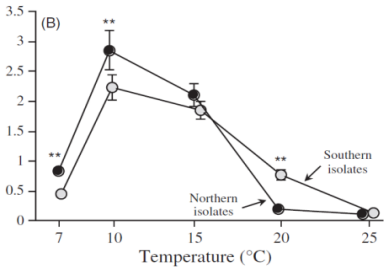
Puccinia striiformis

➢ Wheat yellow rust

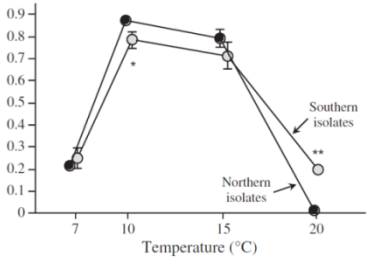
- 17 isolates from two French areas (North and South)
- Tested at five temperatures (7-25°C)

Mboup *et al.*, 2011

Infectivity (fraction of sporulating lesions per cm²)



Proportion of germinated spores



➢ **Pattern of temperature-dependant local adaptation**

❑ What do we know about *Phythophthora infestans*?

➢ Effects of temperature on different clonal lineages

- ❖ **Brazil**: BR-1 & US-1 (Maziero *et al.*, 2009)
- ❖ **USA**: US-1, US-7 & US-8 (Mizubuti & Fry, 1998)
- ❖ **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

Introduction

Objectives of this study:

- Investigate the temperature reaction norms for three life history traits of *P. infestans* isolates
  - from geographically separated populations
    - Local adaptation?

Or

  - from different clonal lineages (6_A1 vs 13_A2)

Materials & Methods

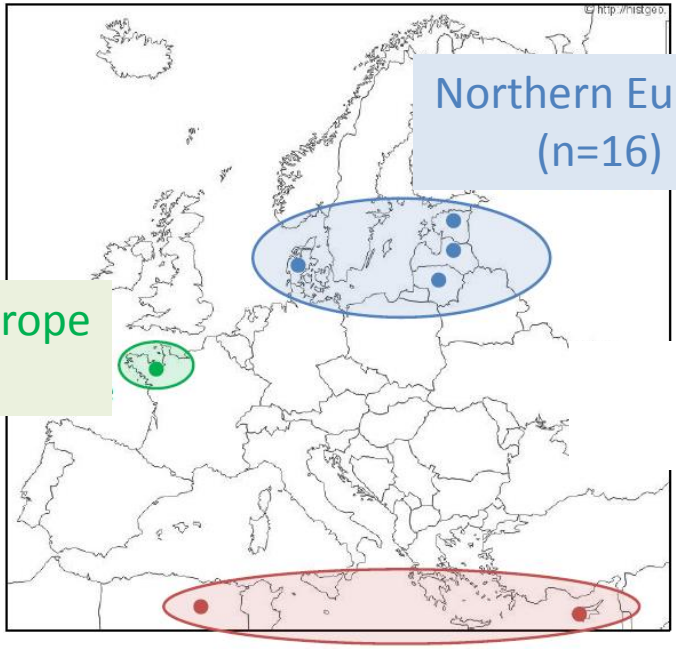
Materials & Methods

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

Average temperatures (°C)		
Annual	Min	Max
11.5	5.8	17.5

Western Europe (n=17)

13_A2 (n=8)
vs 6_A1 (n=9)



Average temperatures (°C)		
Annual	Min	Max
5.3 8.4	-5.8 0.4	16.9 17.4

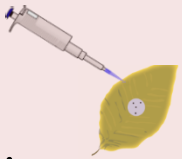
Average temperatures (°C)		
Annual	Min	Max
17.6 19.3	11.5 11.8	25.2 27.6

Climate-data.org

Materials & Methods

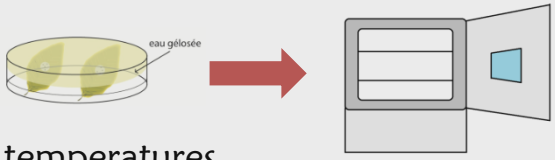
❑ Biological characterization of isolates

1. Inoculation



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

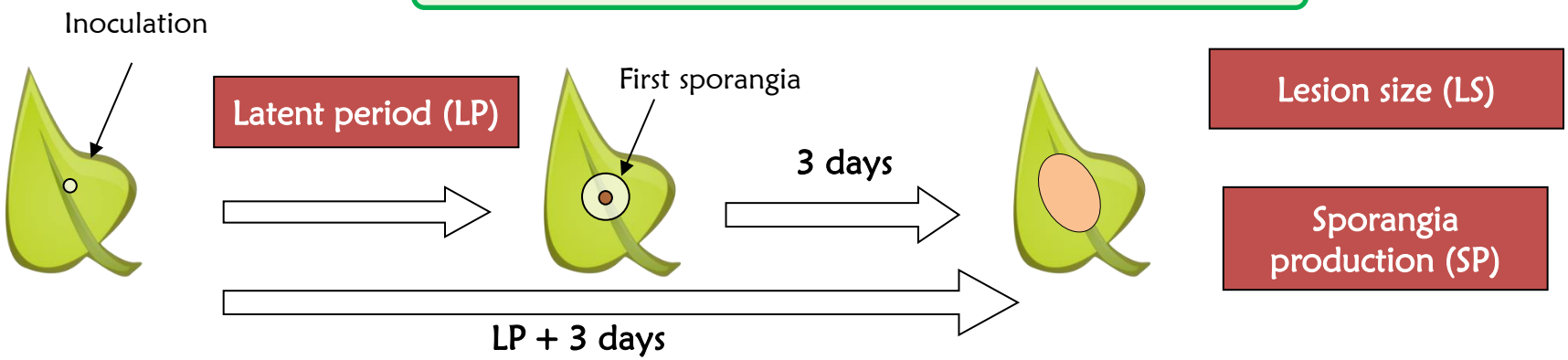
2. Incubation



- 4 temperatures

(10°C, 14°C, 18°C & 24°C)

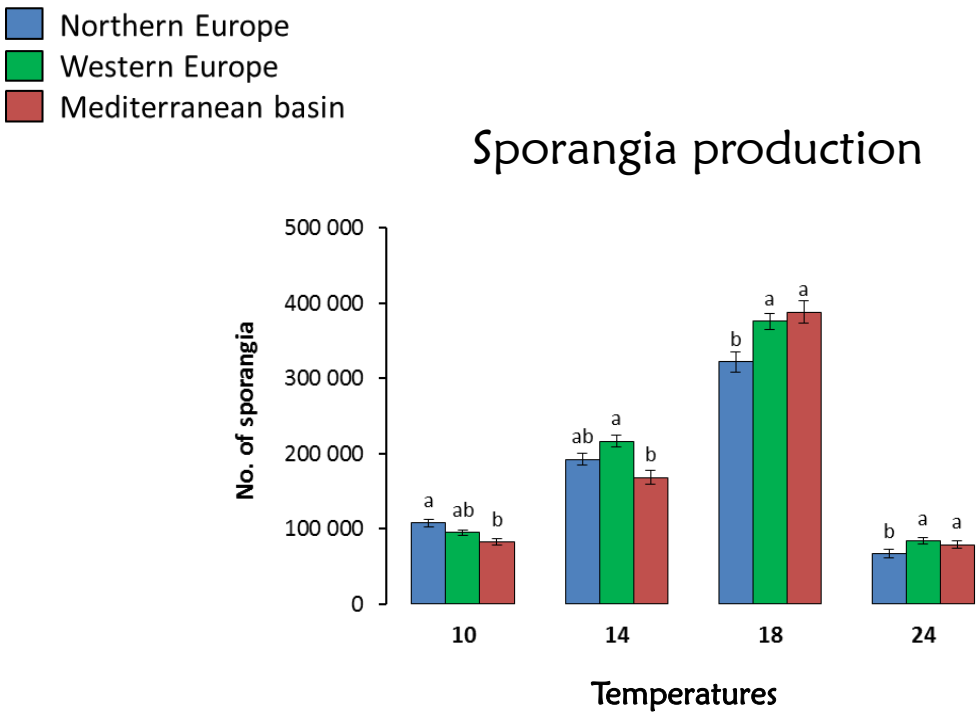
3. Measurement of life history traits



Results

1. Differences between geographical areas

Results



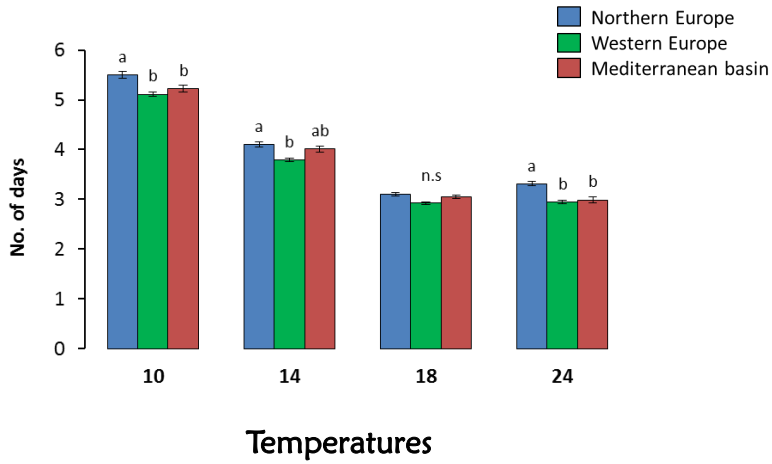
- **A local adaptation pattern?**
  - Northern isolates slightly better at 10°C and less well performing at 18°C & 24°C
  - Conversely for Mediterranean isolates
  - Western isolates slightly better performing at 14°C

Statistical analysis

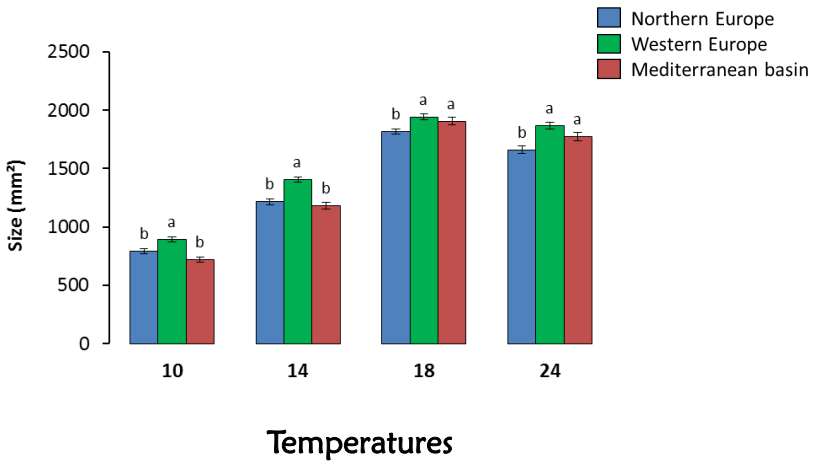
- Linear mixed effects models (fixed factors : temperature & geographical origin; random factors) (R, package lme4)
- Effect of fixed factors : Wald test (R, package car)
- Post-hoc comparison with the Least Squares Means (R, package lsmeans)

Results

Latent period



Lesion Size



- **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)

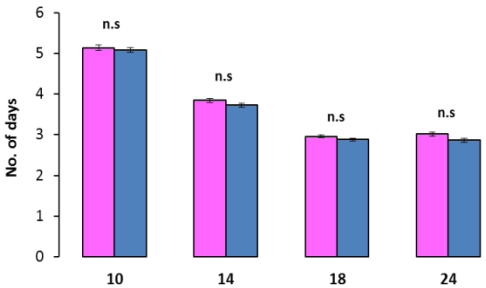
Results

2. Differences between clonal lineages

Results

6_A1
13_A2

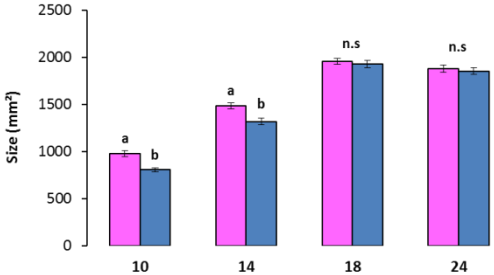
Latent period



Temperatures

- Same latent periods for 13_A2 & 6_A1 isolates

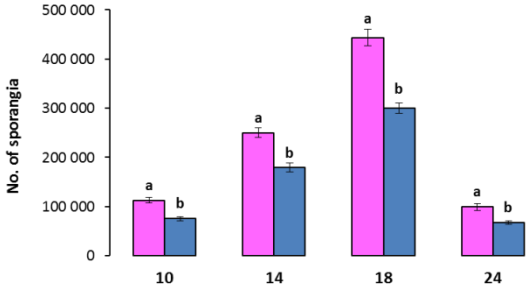
Lesion size



Temperatures

- 6_A1 isolates cause larger lesions at low temperatures

Sporangia production



Temperatures

- 6_A1 isolates produce more sporangia at all temperatures

Discussion

Discussion

- A local adaptation pattern detected for sporangia production

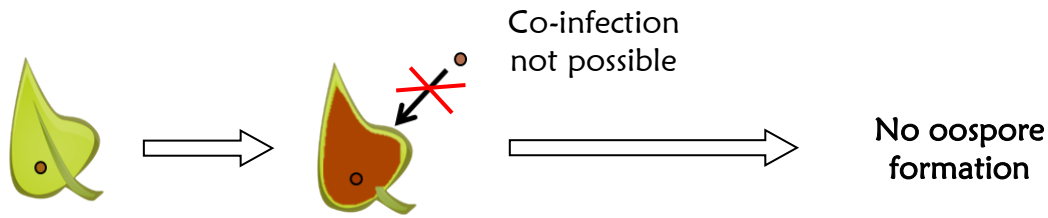
- No local adaptation patterns detected for the other traits
  - Northern isolates generally have long latent periods and low lesion growth rates

Discussion

How to explain the relative low performances of the Northern isolates for latent period and the lesion size?

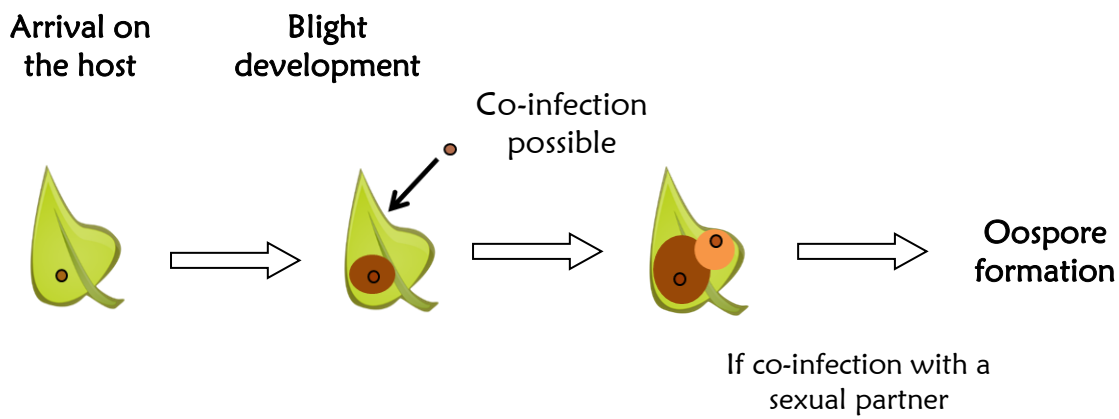
"Fast" isolate

- Short latent period
- High lesion growth rate



"Slow" isolate

- Long latent period
- Low lesion growth rate



Discussion

How to explain the relative low performances of the Northern isolates for latent period and the lesion size?

In Northern Europe

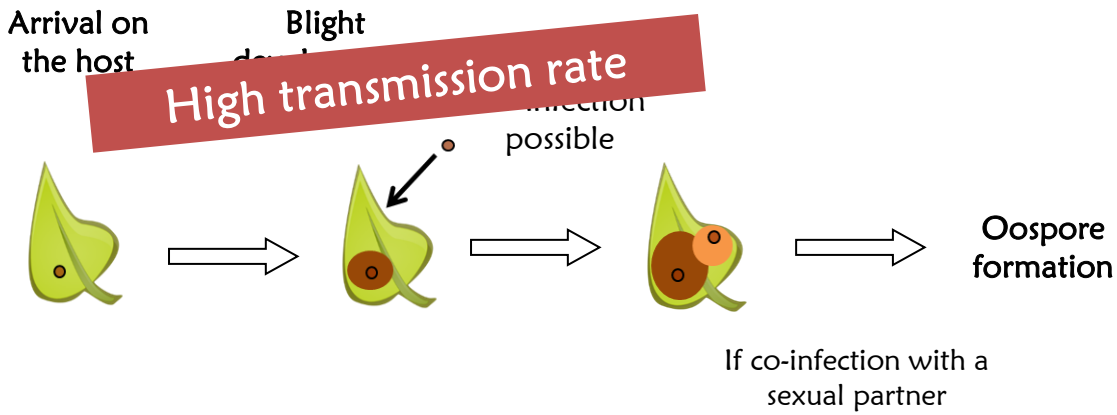
- Cold winters avoid the asexual survival of *P. infestans*

"Fast" isolate

- Short latent period
- High lesion growth rate

"Slow" isolate

- Long latent period
- Low lesion growth rate



- If progeny have the pathogenic characteristics of their parents
- It could explain the selection of "slow" isolates in Northern Europe

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 (ex. sporangia size)?

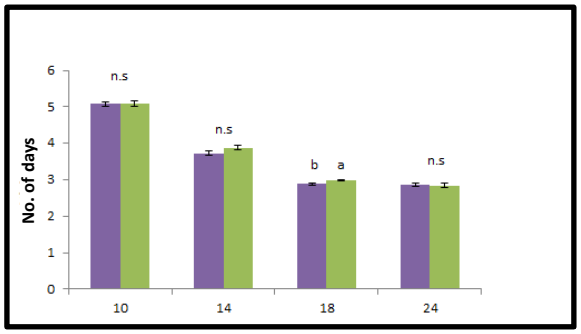
Cf. Poster of Mabon *et al.*

- 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)

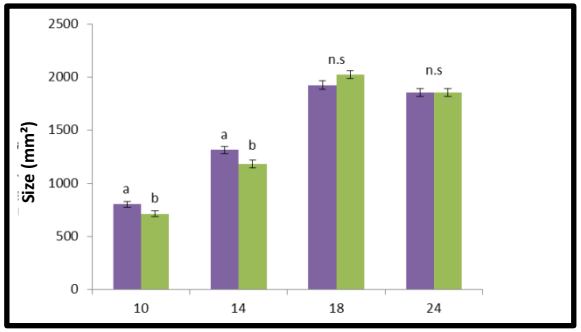
Discussion

Temperature responses of 13_A2 isolates from **Western Europe** ■
& **Mediterranean basin** ■

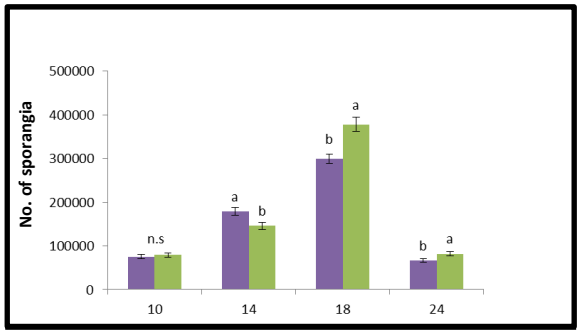
Latent period



Lesion size



Sporangia production



- **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:

The contributors of this study:

A. Androdias, R. Mabon, R. Corbière, B. Marquer, J. Montarry & D. Andrivon

The suppliers of *P. infestans* isolates:

Dr. E. Runno-Paurson, Dr. B. Nielsen & Dr. Z. Bouznad

The funders of my PhD:

The Members of ACVNPT (French Association of Potato Breeders)

GERMICOPA

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Bretagne-Plants

Comité Nord
Plants de Pommes de Terre

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…And You for your attention!!