Multiple infections and reproductive strategies in *Phytophthora infestans*

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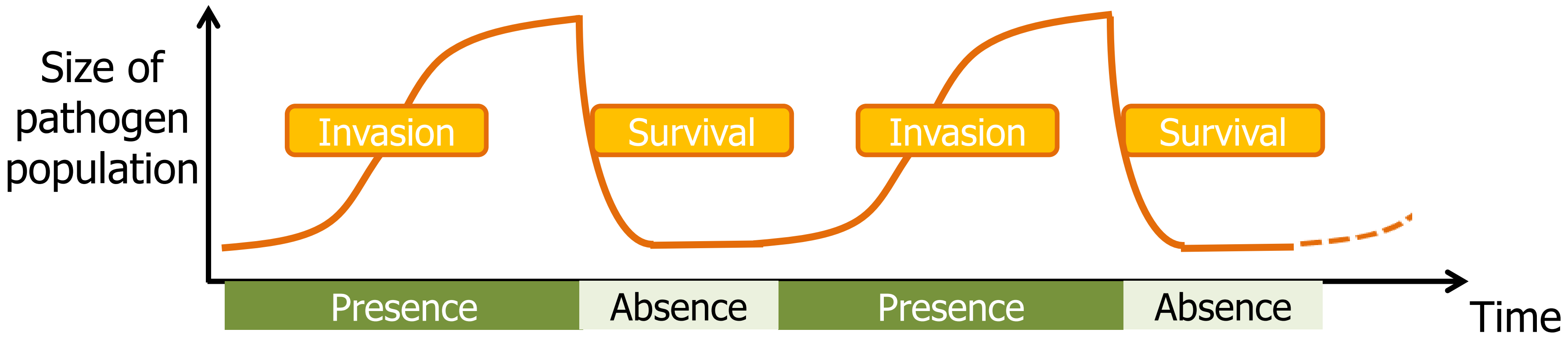
Host availability and epidemic dynamics

- Agrosystems = alternance of host presence and absence

=> epidemic dynamics = alternance of pathogen invasion and survival



Pathogen life history traits

- **To invade:**

  host colonisation and
  host to host transmission

  - Growth in host
    ➔ *mycelium growth rate*
  - Pathogen dissemination
    ➔ *sporangia production*
  - *Many cycles*
    ➔ *short latent period*
    ➔ *asexual cycle*

- **To survive:**

  primary inoculum
  for the next season

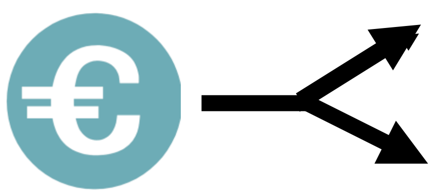
  - **asexual**
  - **sexual**

Trade offs between life history traits

- The perfect parasite would maximise both invasion and survival...
- … but theory shows this can’t be done

➔ **so trade offs exist**

- For individuals: ressource allocation



Asexual multiplication

Sexual reproduction

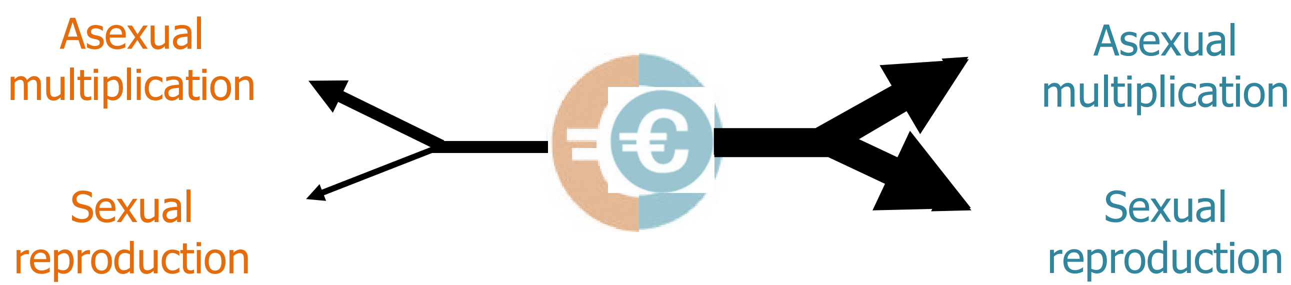
- For populations: selection of the strategies maximising fitness, not each trait

Roff, 1992; Stearns, 1992

Modulation of reproduction strategies

- **How?**
  - More intense exploitation of host = increasing available ressources
  - Changing resource allocation between traits/functions

- **What if more than one infection?**
  - Sharing ressources > changes in host exploitation or ressource allocation?



Mideo, 2009

The case of heterothallic species

- Type of offspring depends on multiple infections
- Sex occurs only between compatible partners

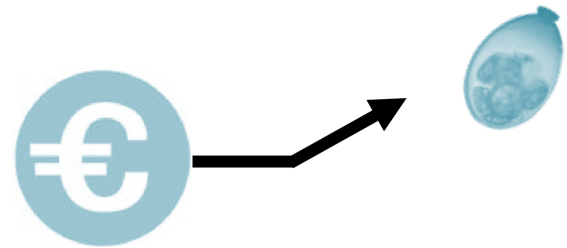
  ➔ Dissociate effects of

  * multiple infections
  * differential allocation of ressources into both modes of reproduction

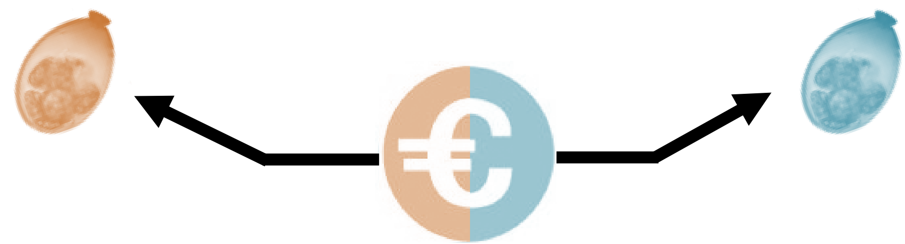
- *P. infestans* a good model to look at this

Infection situations in *P. infestans*

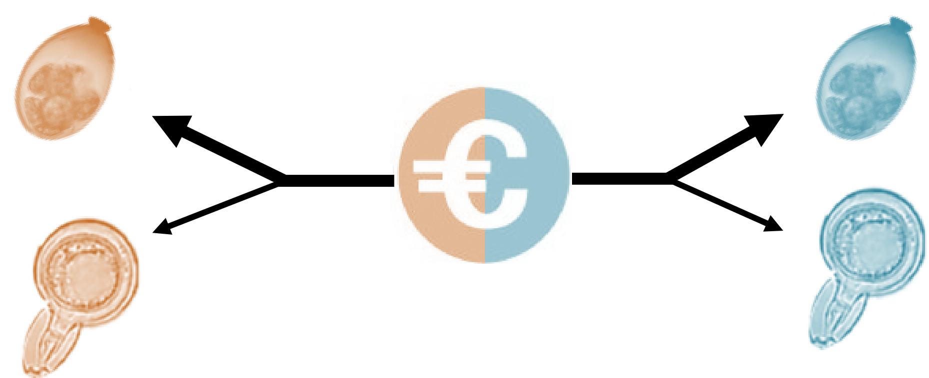
- **Single infections**



- **Multiple infections**
  - Incompatible
    (A1+A1 or A2+A2)

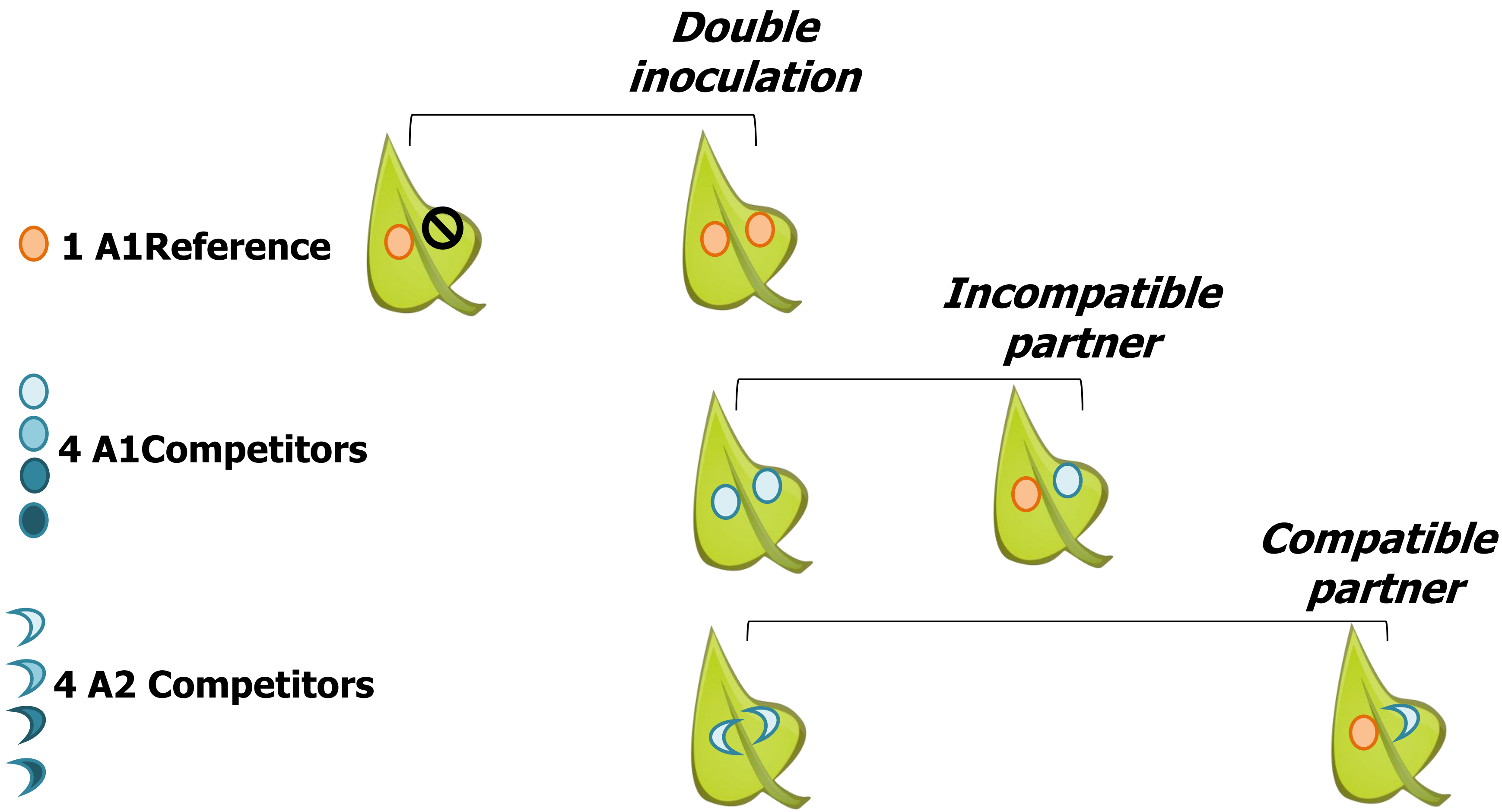


  - compatible
    (A1+A2)
  - ➔ sexual reproduction



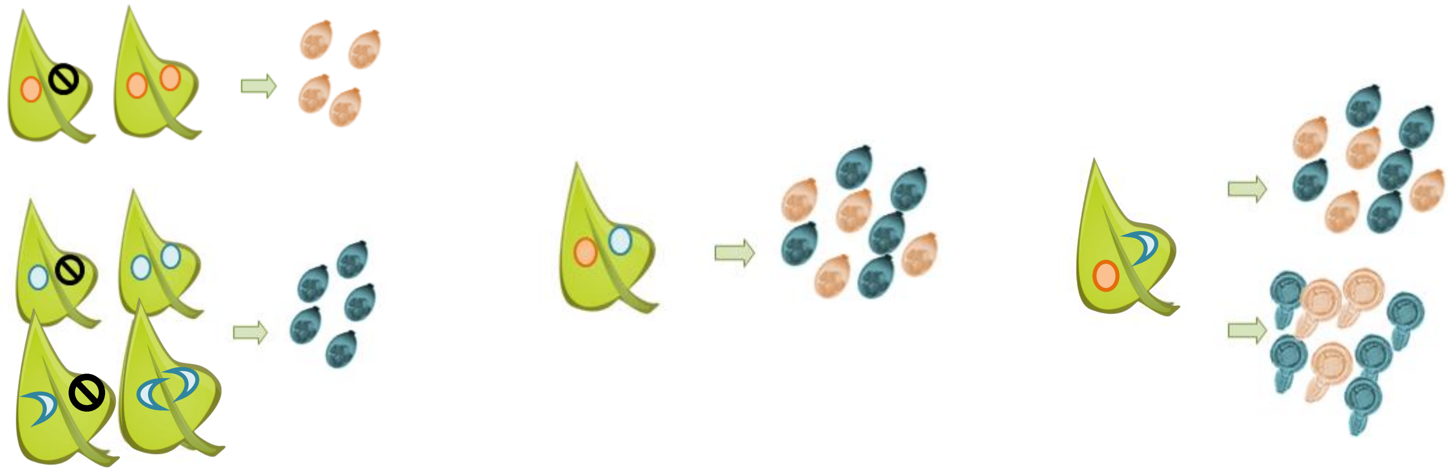
Experimental plan

- One susceptible host : Bintje
- Inoculation scheme allowing to dissociate effects



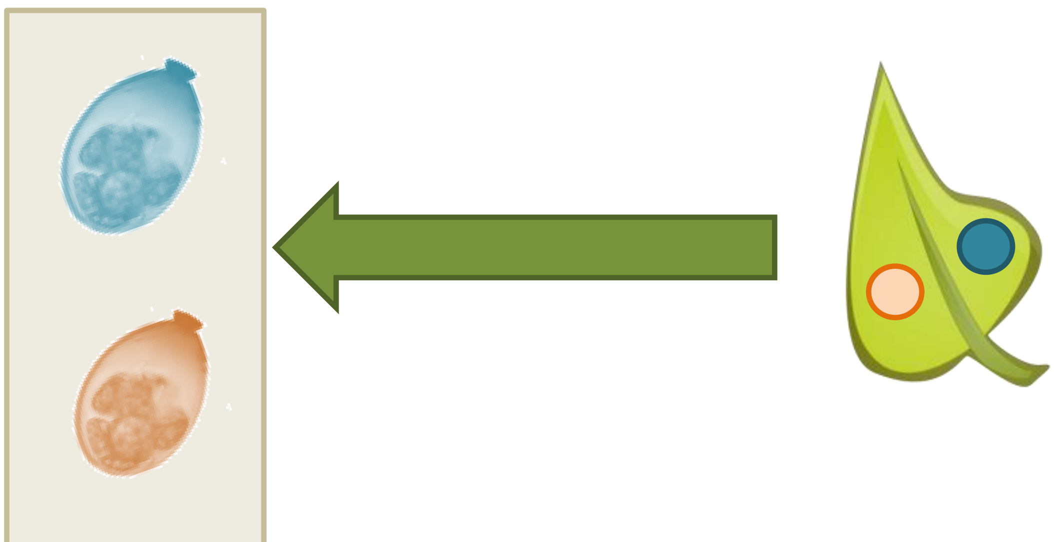
What was measured

- Offspring number…



- … separating sexual and asexual offspring
- … quantifying the contribution of each isolate to each pool
  - through a **qPCR tool giving, for each isolate**
    - copy numbers of the parental allele in sporangia/zoospores
    - copy numbers of the parental allele in oospores (if sex)

MULTIPLE INFECTIONS AND ASEXUAL MULTIPLICATION



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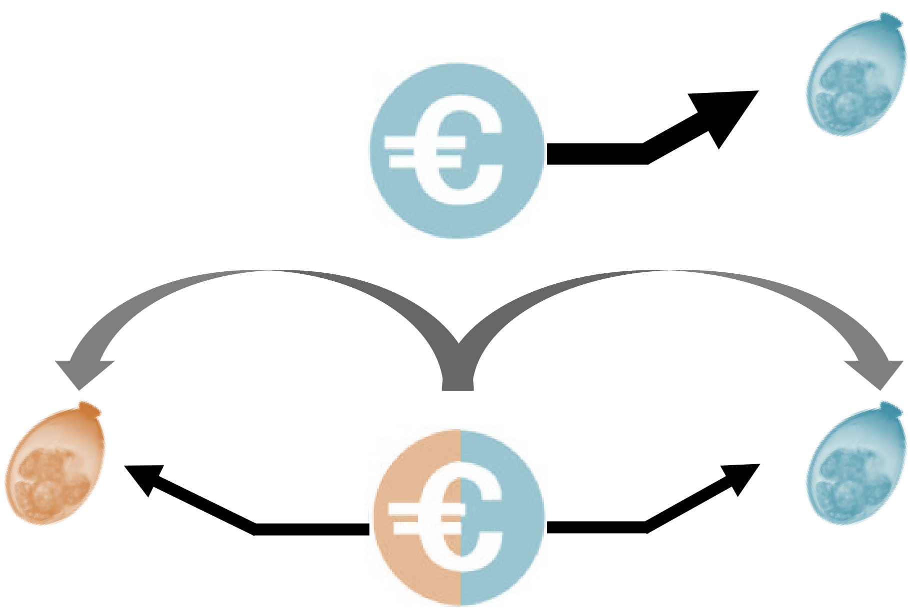
What is expected?

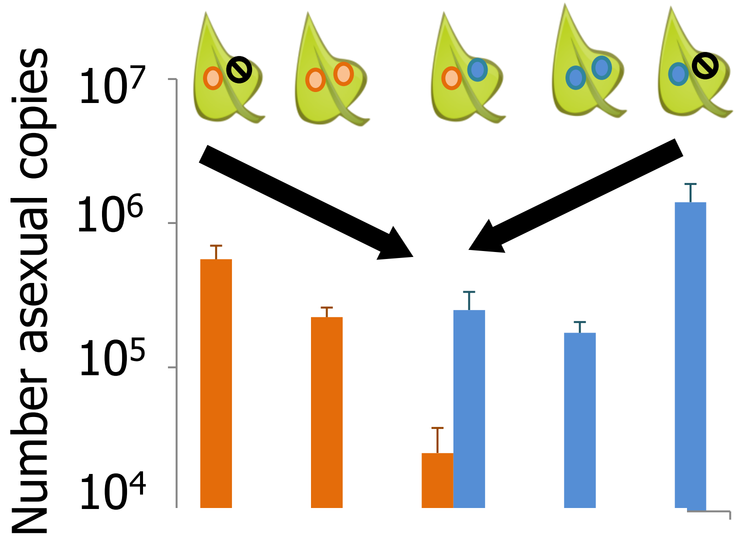
- Theory says
  - Host ressources have to be shared
  - Competition for space > more allocation in growth

➔ **Prediction : less asexual multiplication in multiple infections**



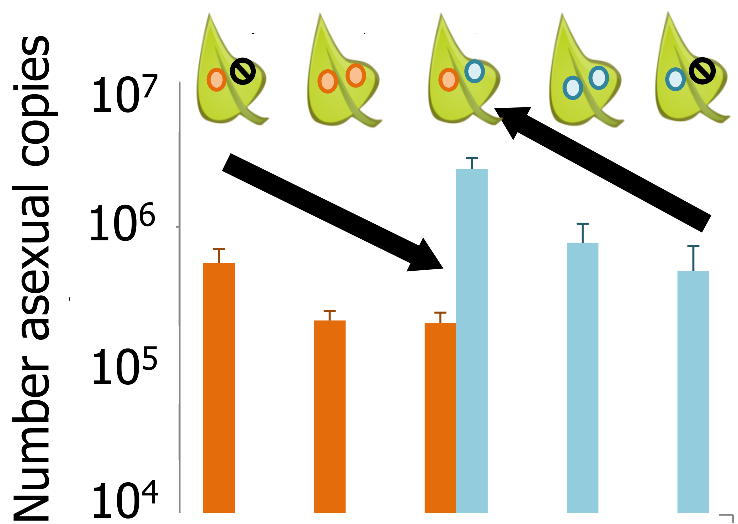
Mideo, 2009

What actually occurs: two different strategies



Non Competitive **NC**

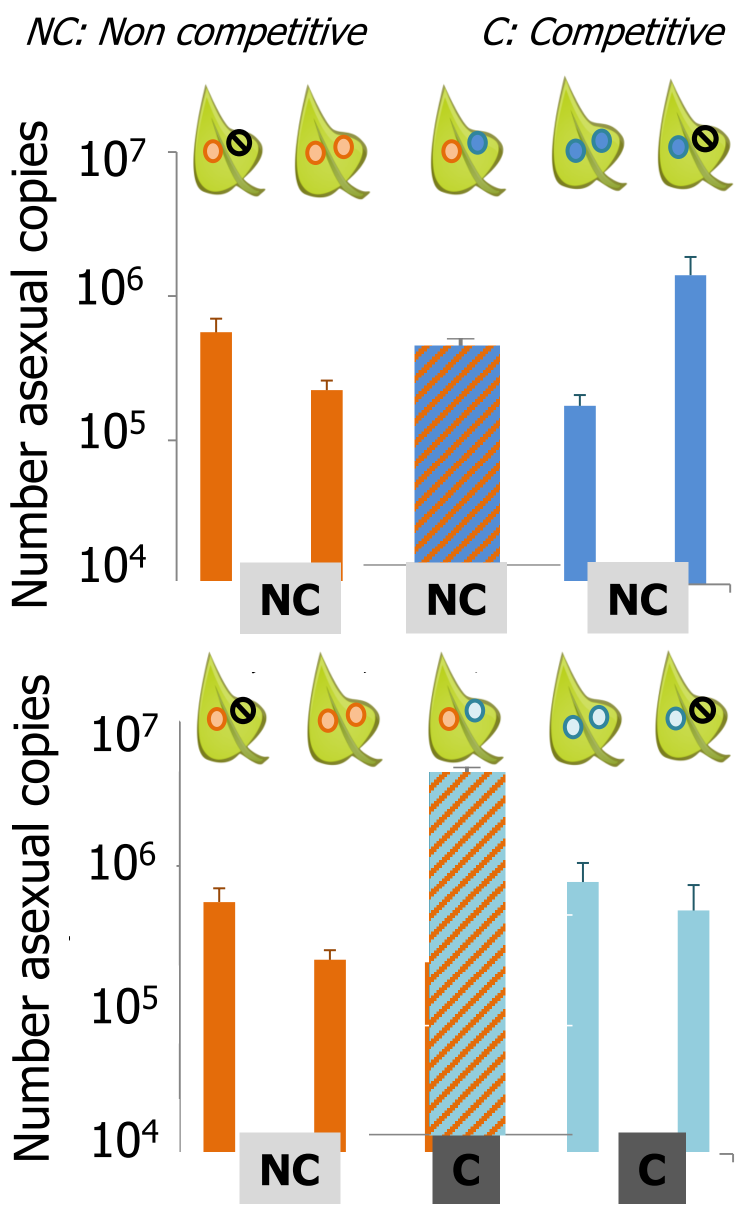
➔ 2 isolates out of 5 tested



Competitive **C**

➔ 3 isolates out of 5 tested

Collective host exploitation



All host tissue colonised at the end of experiments

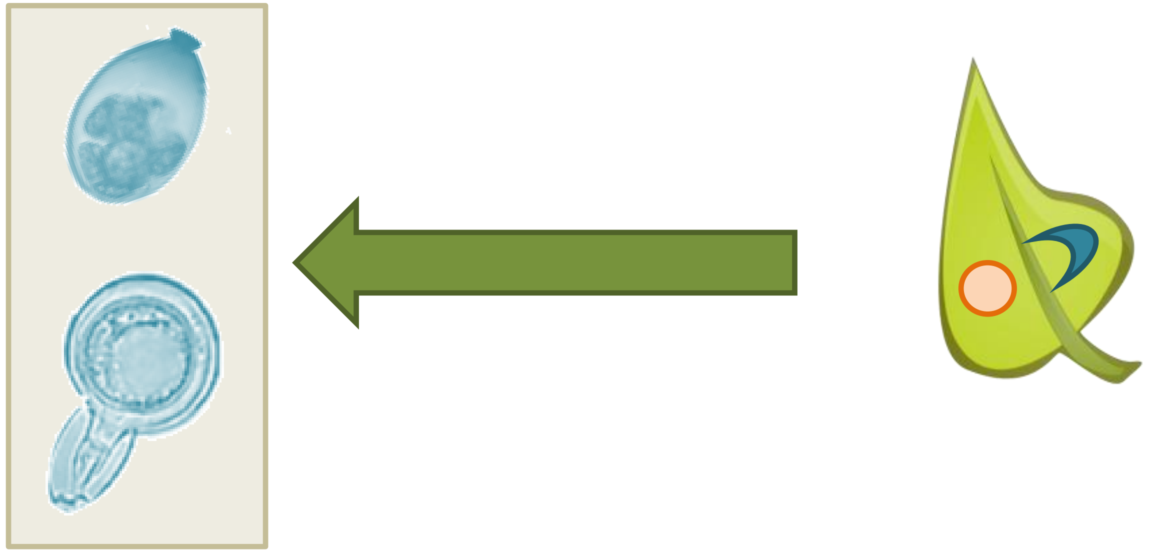
⇨ Depends on pairs of individual strategies

⇨NC+ NC= NC

⇨NC+C = C

What if sex is possible?

SEXUAL COMPATIBILITY AND REPRODUCTION STRATEGIES



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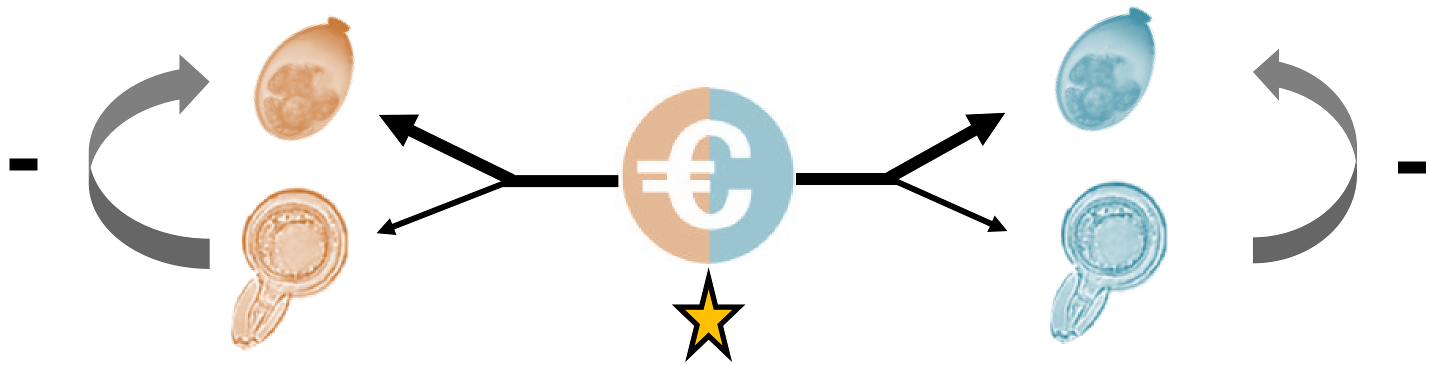
Question and hypotheses

- **Does investing in sexual reproduction alters the investment in asexual multiplication?**



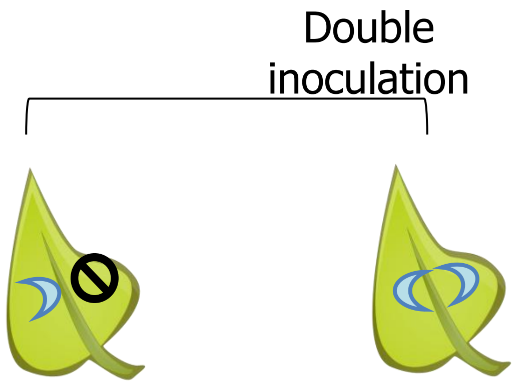
- **Theory says**
  - Expressing a new trait (sex) requires part of the ressource budget
  - The energetic cost of sex is higher than that of asexual multiplication

  - **Predictions**
    - ➔ **Asexual multiplication should decrease**
    - ➔ **for both C and NC isolates**

Roff, 1992: Stearns, 1992; Lenormand, 2010

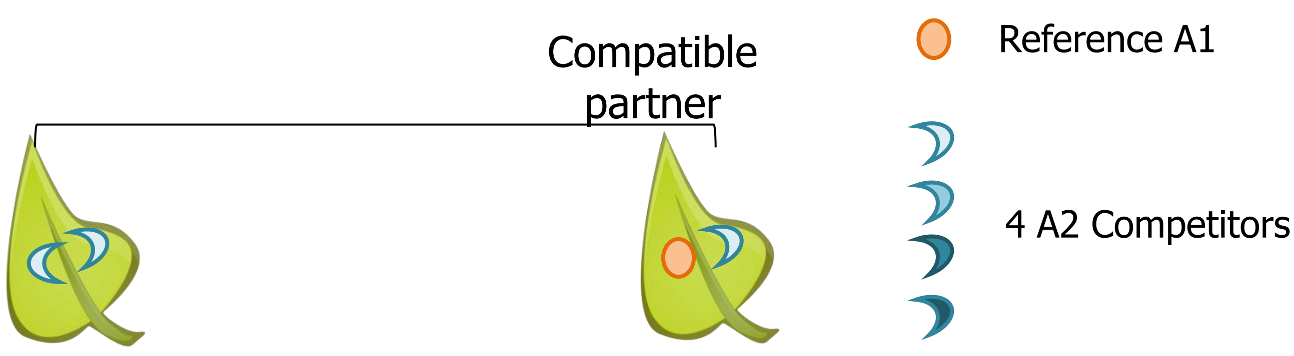
Experimental testing

1. **Defining the strategies of the A2 isolates** through double inoculation

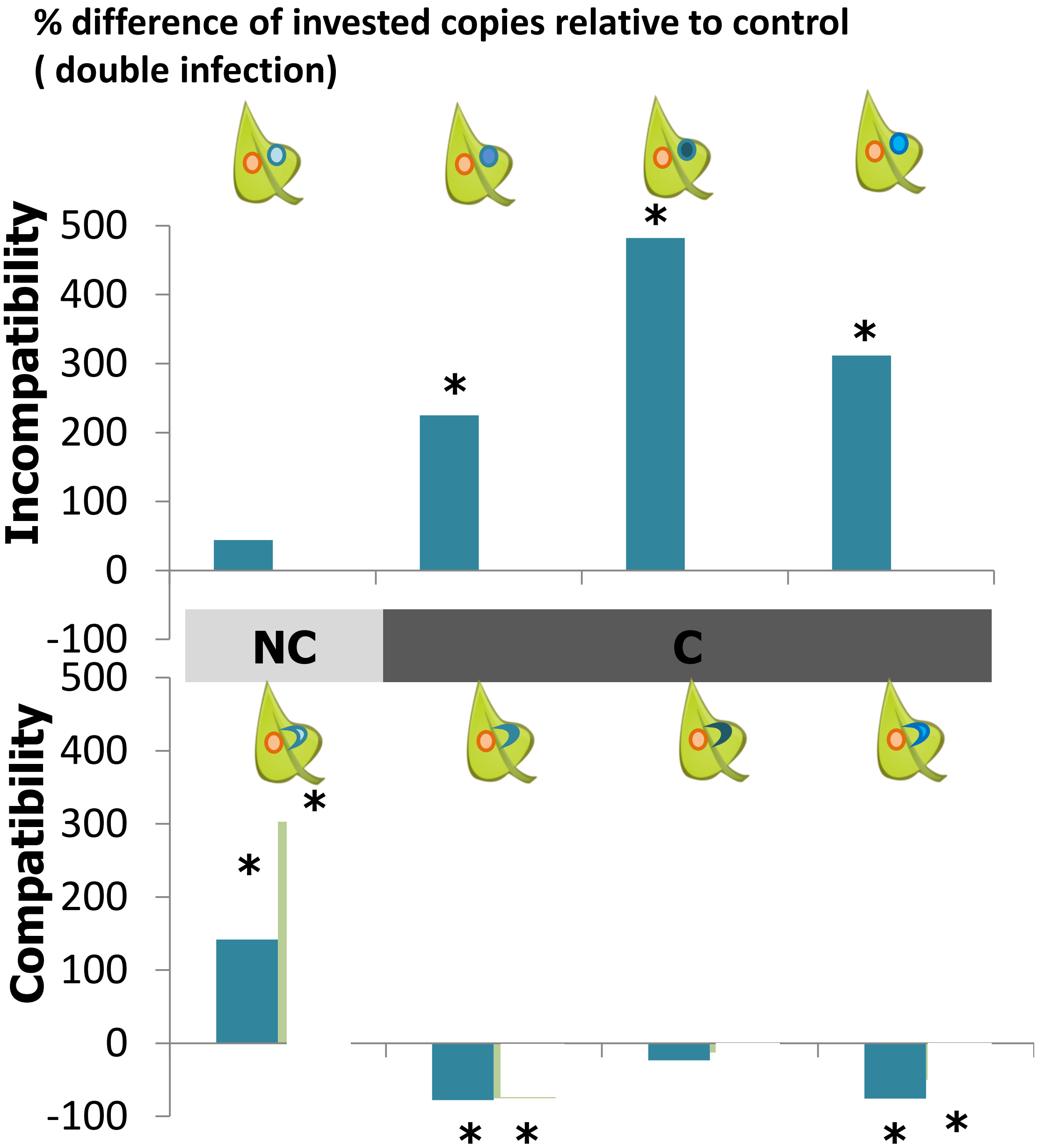


1 NC ; 3 C

2. **Comparing double inoculations with mixed compatible inoculations**



Again two strategies



- **NC isolates**
  - Invest mainly in sexual offspring
  - Produce fewer asexual offspring in incompatible than in compatible pairings
  - **> Survival specialists**?
- **C Isolates**
  - Invest mainly in asexual multiplication
  - Perform less in compatible pairings
  - **> Invasion specialists?**

To sum up

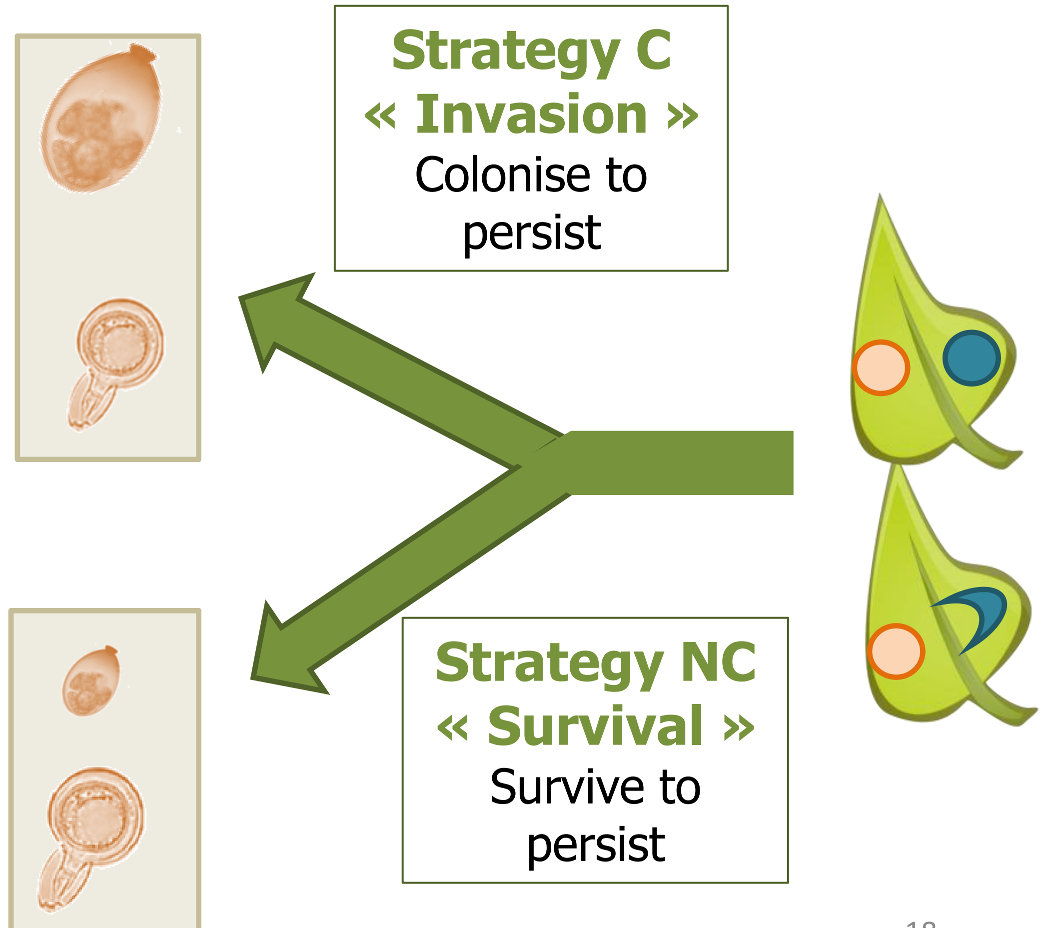
- **Two reproductive strategies**

- Coexisting within populations

- •With evolutionary / adaptive significance

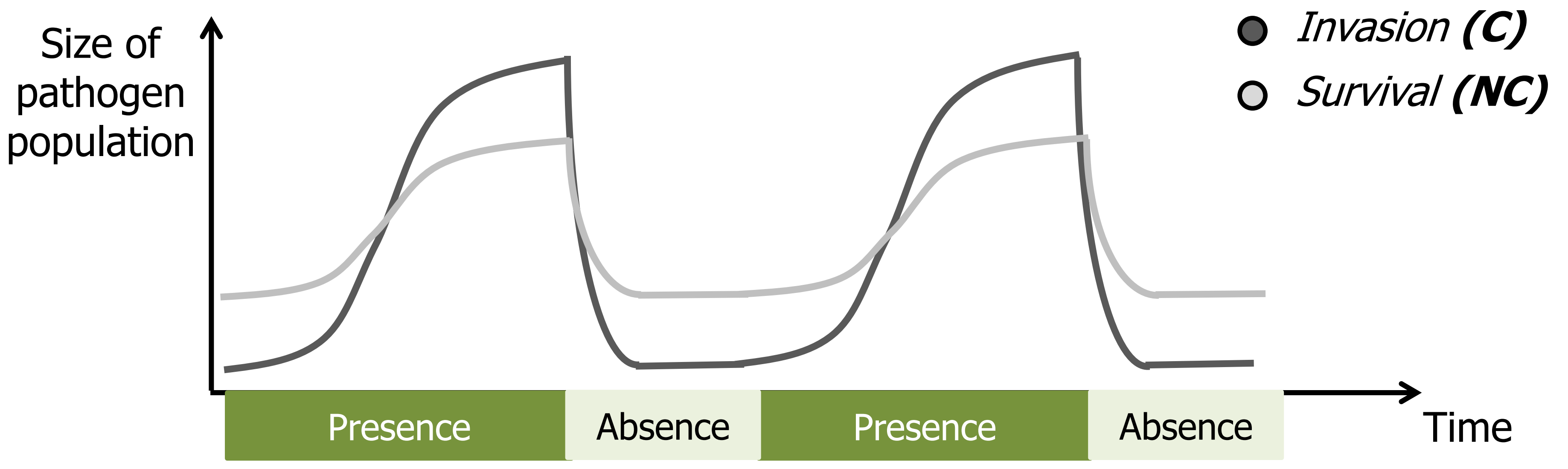
- •With ecological consequences

Never shown before in parasites



Explaining the coexistence

- **Hypothesis**:
  - Different epidemic dynamics for both groups
    ➔ possible verification through population surveys



Exploring the consequences with evolutionary ecology models

- Integrate parameters
  - Relative to the host ⇨ resistance
  - Relative to the pathogen ⇨ LHT and trade-offs

- Reasonning at longer time scales
  - Seasonnality
  - Primary inoculum build-up

- Helping with resistance breeding and management
  - Testing resistance durability *a priori*

Thank you

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- Ludovic Mailleret

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