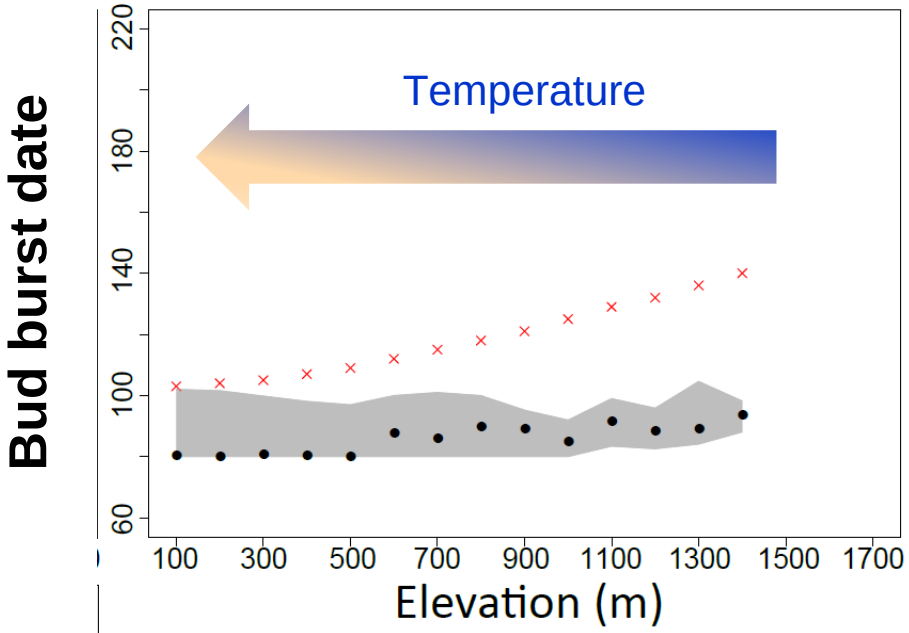
Evolution of plant phenology under a changing climate: insights from quantitative genetics models.

Ophélie Ronce, Claire Godineau , FannyLaugier, Céline Devaux,Jean-Paul Soularue, Cyril Firmat, Sylvain Delzon, Antoine Kremer

Plastic changes in phenology contribute to a large part of contemporary responses to climate change

Impact on fitness: is plasticity adaptive?



Quercus petraea

× Plastic date
● Optimal date
■ Opt range

Hyperplasticity?

Gaüzere *et al.* 2020 *Evolution Letters*

Rapid genetic evolution of phenology in response to climate change

Brassica rapa

Hamann et al. 2018

Plants from 1997 flower 3 days later than plants from 2014 in a common garden

Is fast evolution rare or common?

Variation in phenology affects gene flow and mating patterns


Cole & Sheldon 2017

Assortative mating :
preferential mating among individuals with similar phenotype

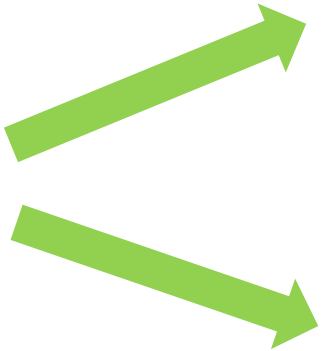
Correlation between mates for flowering time 5%-60%

Weis 2014

How does assortative mating affect phenology responses to climate change?

How does assortative mating affect phenology responses to climate change?

Assortative mating for phenology

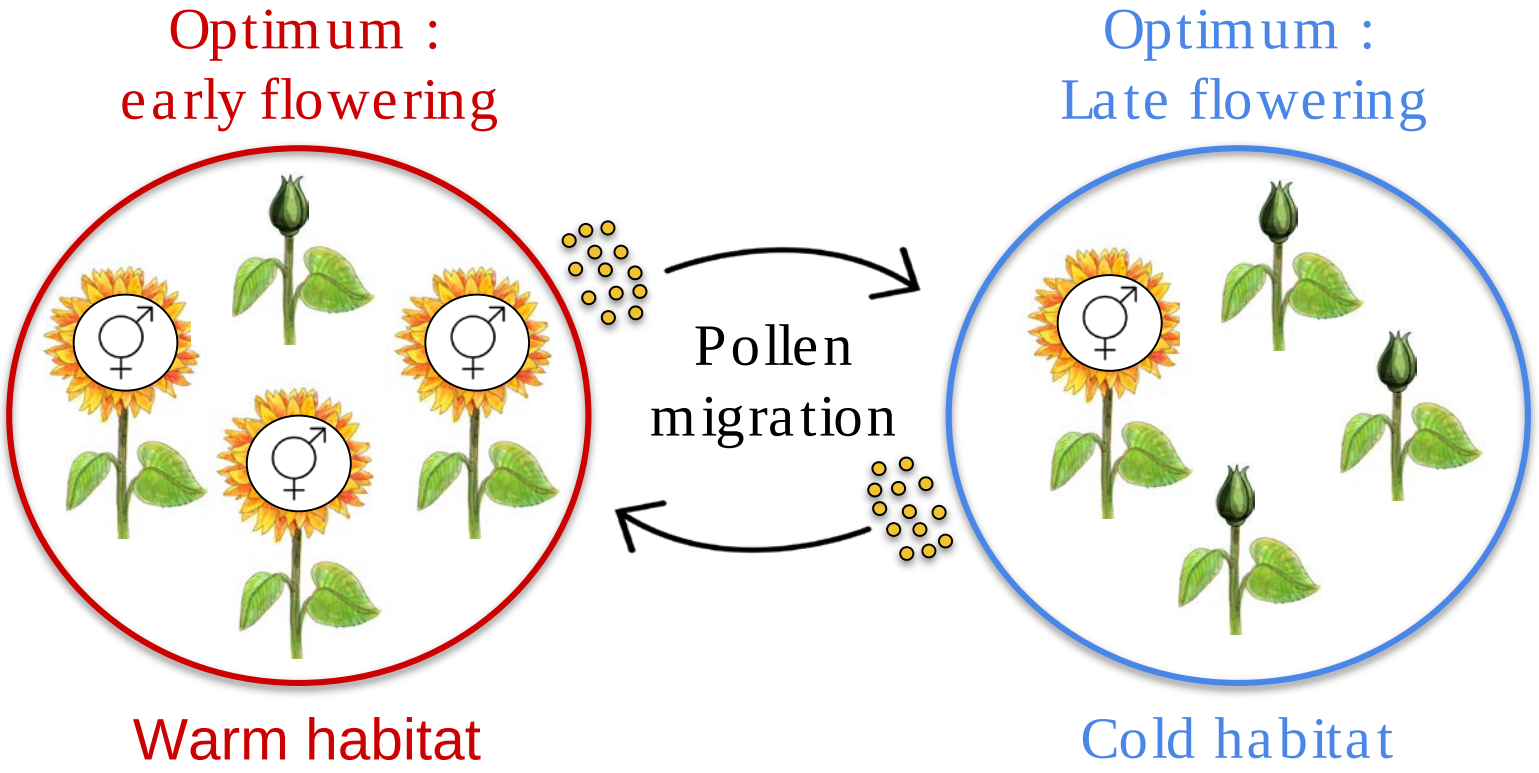


Plastic changes in phenology

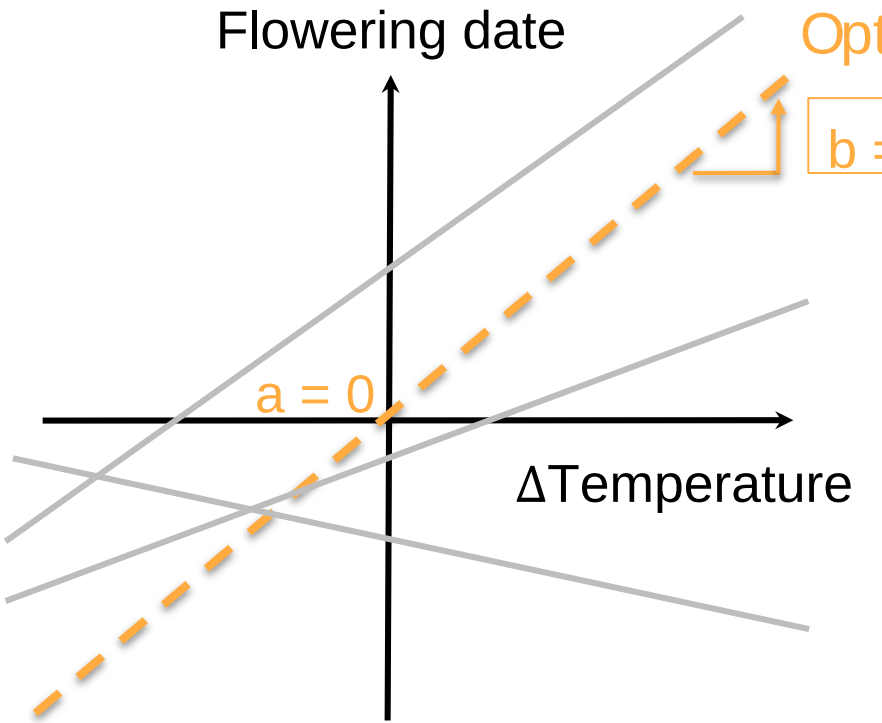
Fast genetic evolution of phenology

Mathematical models and individual-based simulations

A simple model for the evolution of flowering phenology in a heterogeneous environment



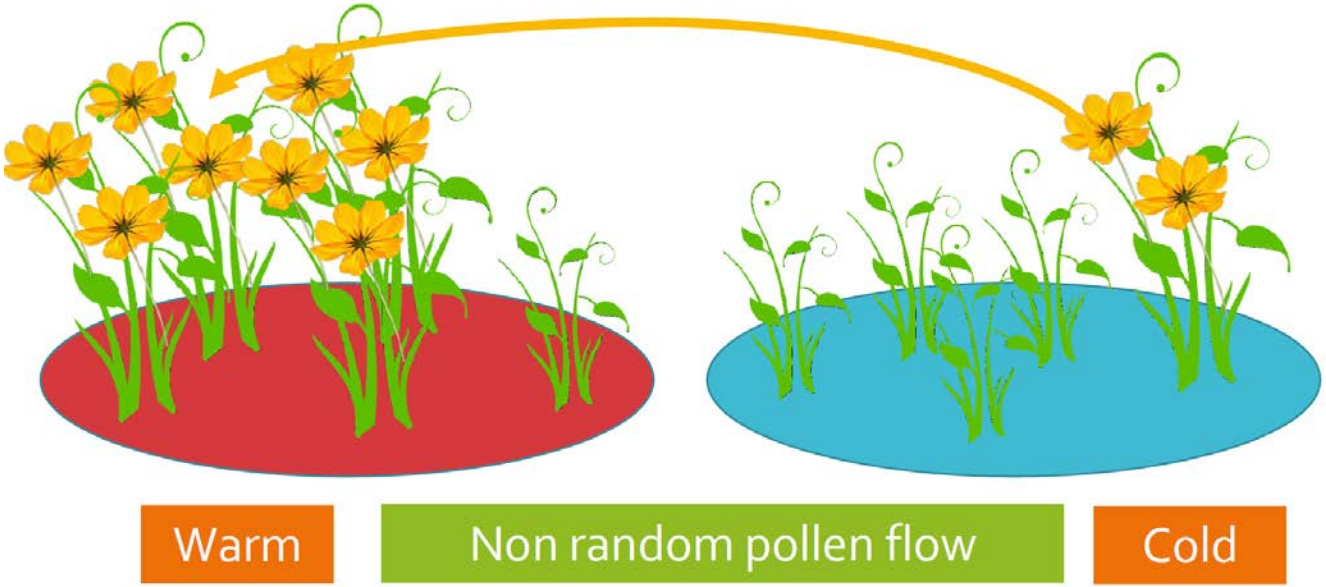
Plasticity of flowering date varies between individuals and is heritable



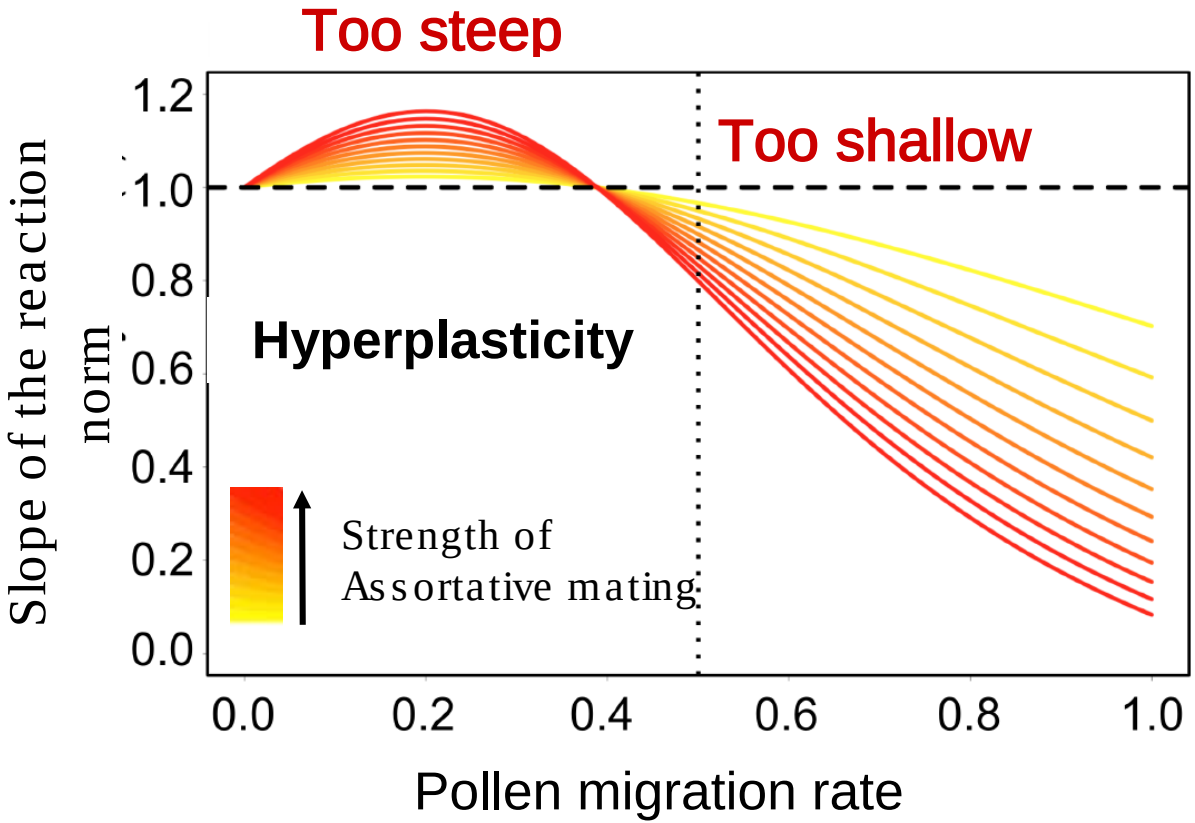
Both the slope *b* and the elevation *a* of the reaction norm depend on genetic variation at multiple loci

Assortative mating results in non random gene flow across environments

Only genes causing earlier flowering can enter warm environments



With assortative mating, non optimal plasticity evolves



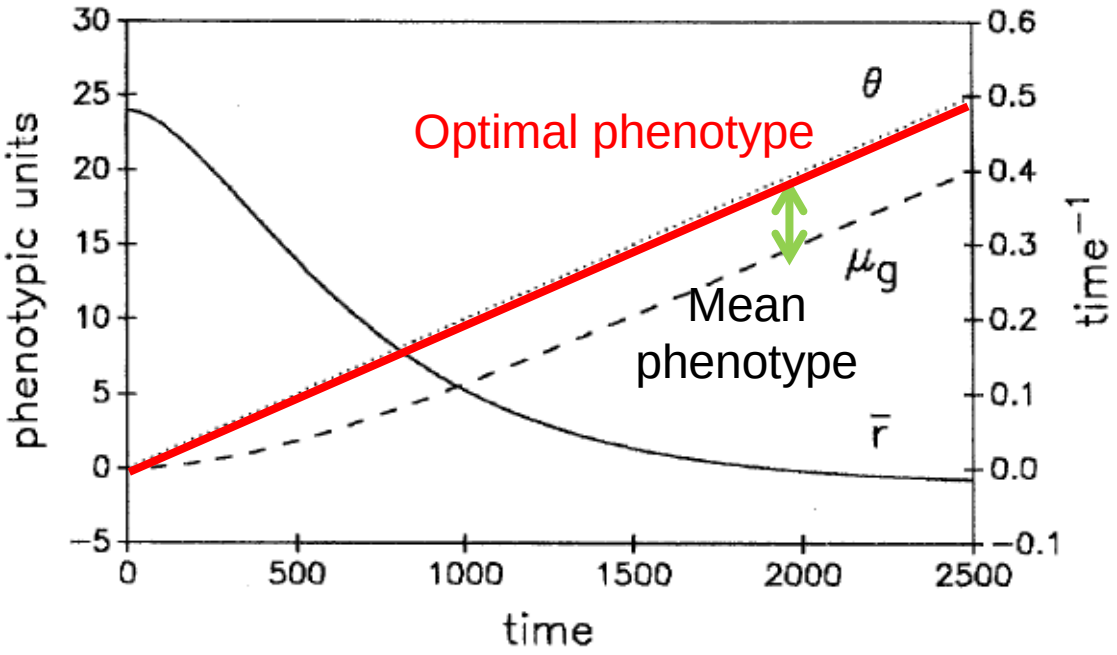
The slope of the reaction norm deviates from the optimal slope

With assortative mating, non optimal plasticity evolves

- Evolution of phenotypic plasticity for flowering time is shaped by conflict between natural and sexual selection

- This conflict depends on the intensity and distance of pollen dispersal

If plasticity is not sufficient to mitigate the negative consequences of climate change, can fast evolution help?

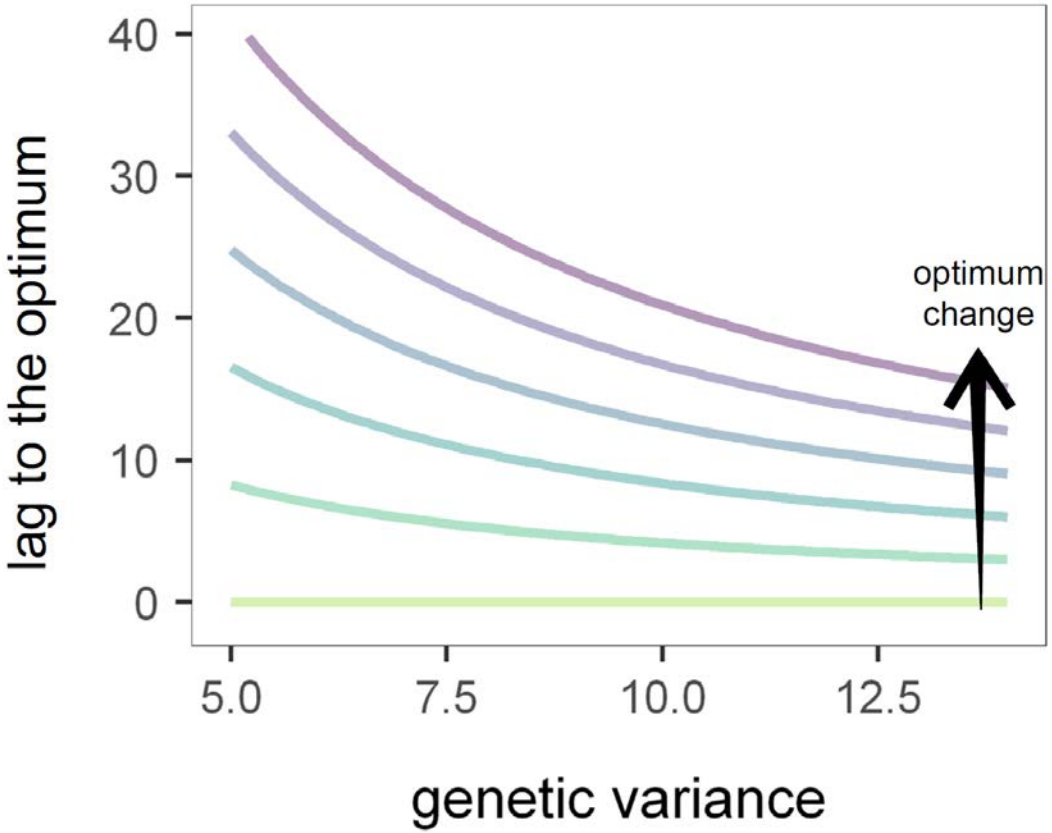


Mean phenotype evolves to track the shifting optimum with a constant lag

The population goes extinct if the evolutionary lag is too large

Lynch et al. 1991

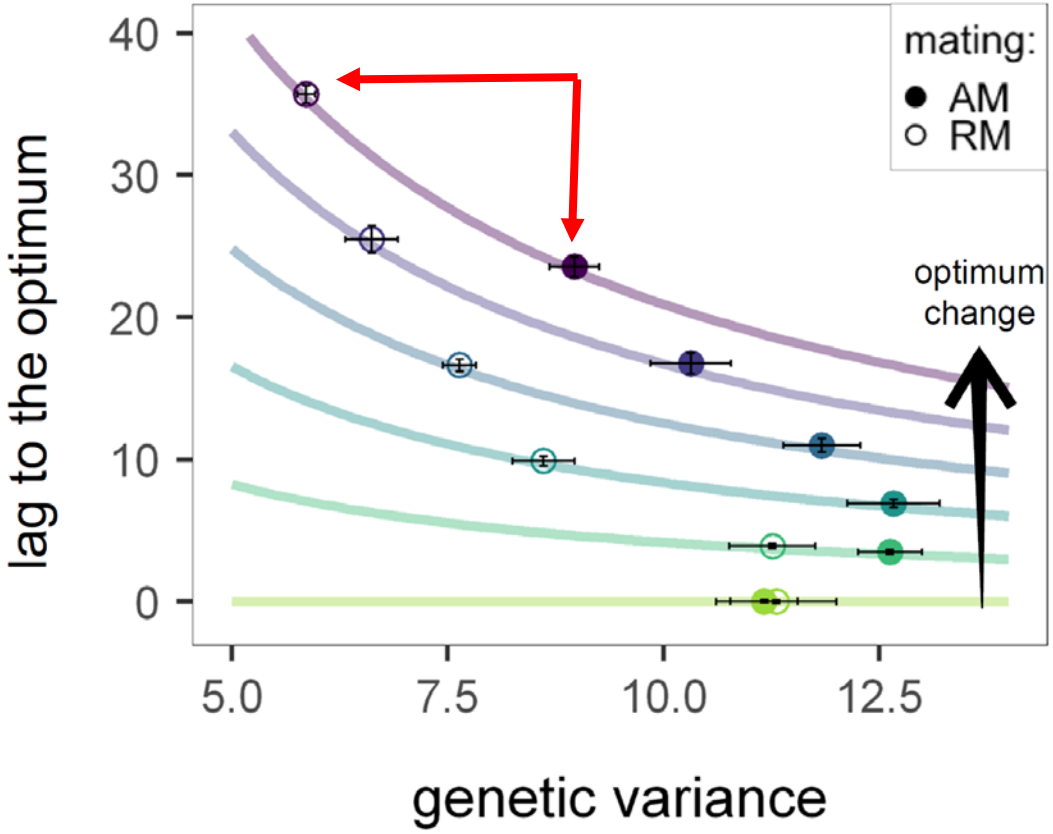
Evolutionary lag is smaller when the genetic diversity for the adapting trait is larger



Can assortative mating for phenology increase the genetic variance?

Godineau *et al.* 2021 Journal of Evolutionary Biology

Evolutionary lag is smaller when the genetic diversity for the adapting trait is larger



Genetic variance is much higher with assortative mating than random mating in a fast changing environment

Lag is smaller with assortative mating

Godineau *et al.* 2021 Journal of Evolutionary Biology

Can assortative mating accelerate evolution in a changing climate?

- Assortative mating for flowering time results in evolution of larger genetic variance in a changing environment than for a trait under random mating, but not in a constant environment
- This higher genetic variance reduces adaptive lags and generally increases fitness under climate change
- Assortative mating could explain the fast responses to climate change of flowering time

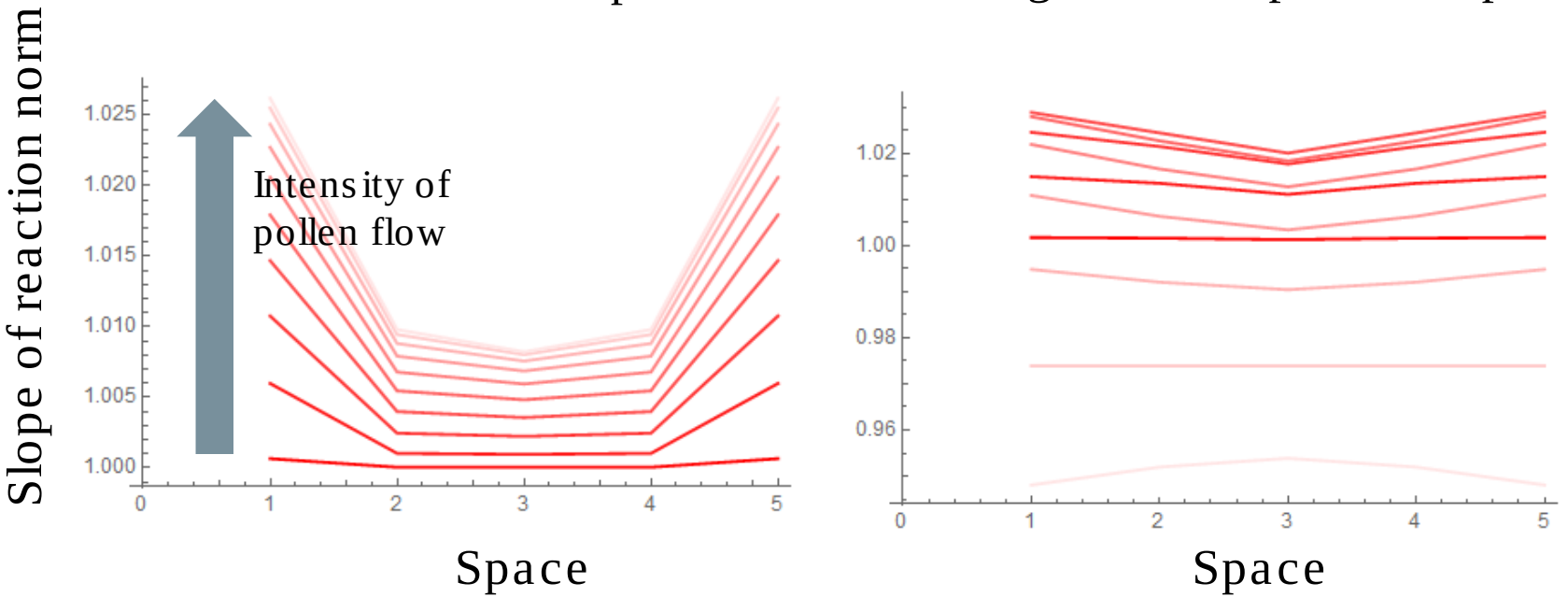
Can assortative mating accelerate evolution in a changing climate?

- Assortative mating for phenology may be both the source of the problem and the solution when adapting to climate change.
- Assortative mating may cause the evolution of maladaptive plasticity in heterogeneous environments
- But it helps maintaining higher genetic variance and thus evolutionary potential in a changing climate

Different types of landscapes: a linear gradient

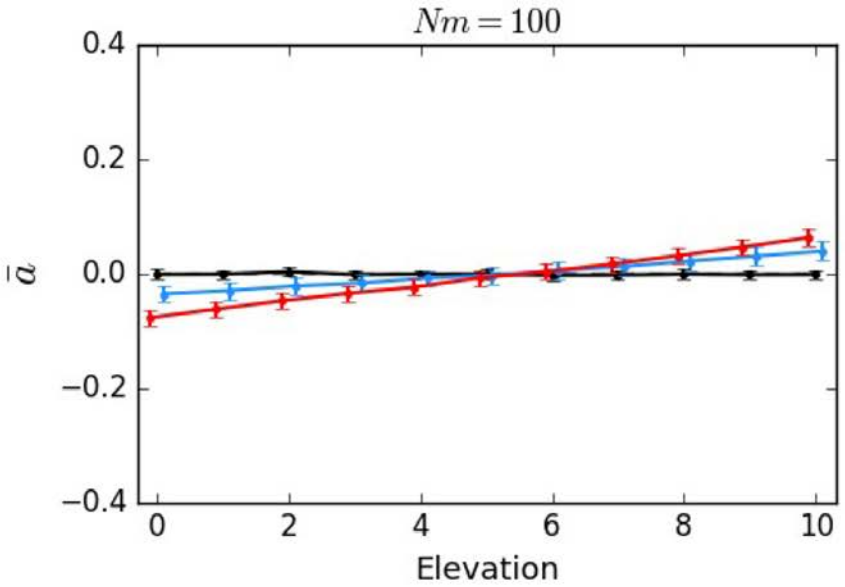
Short distance dispersal

Long distance pollen dispersal

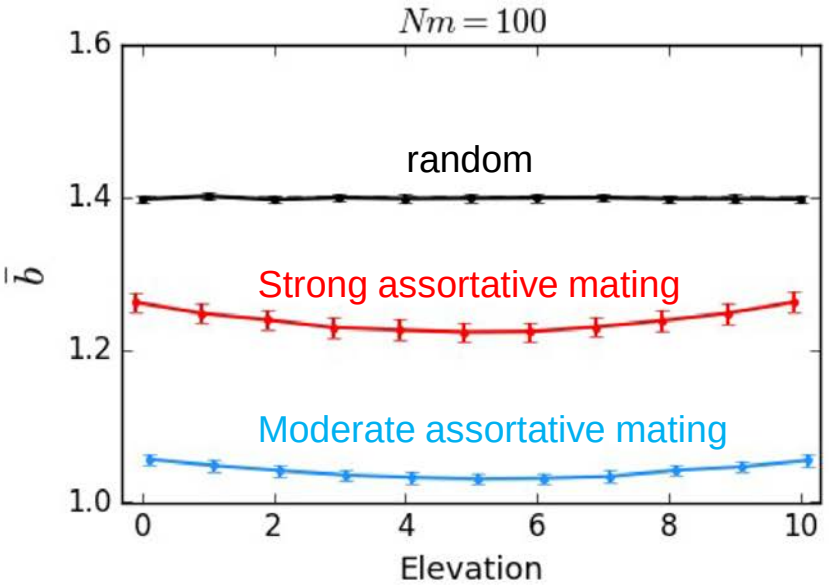


Simulations with long distance gene flow

Intercept of reaction norm



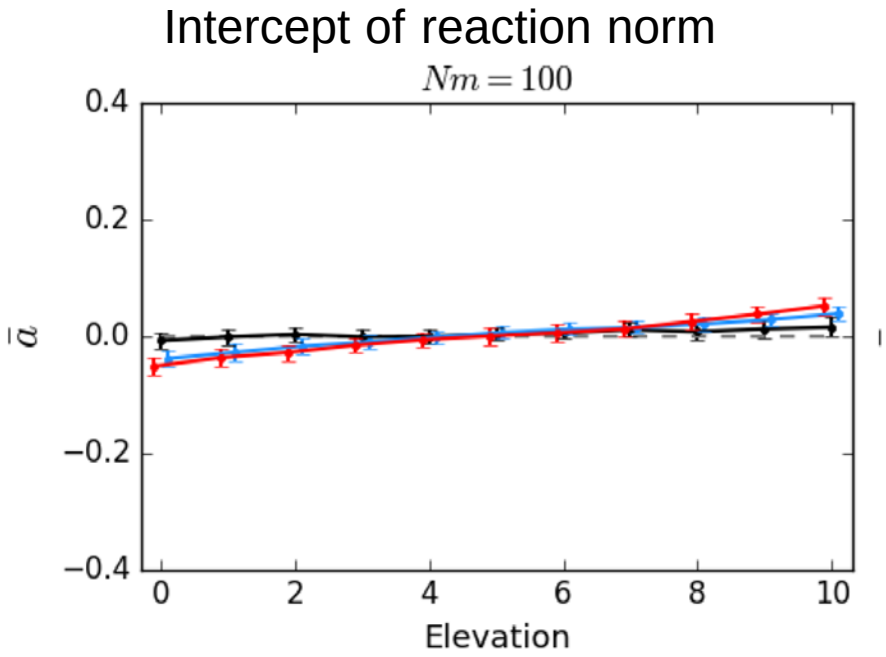
Slope of reaction norm

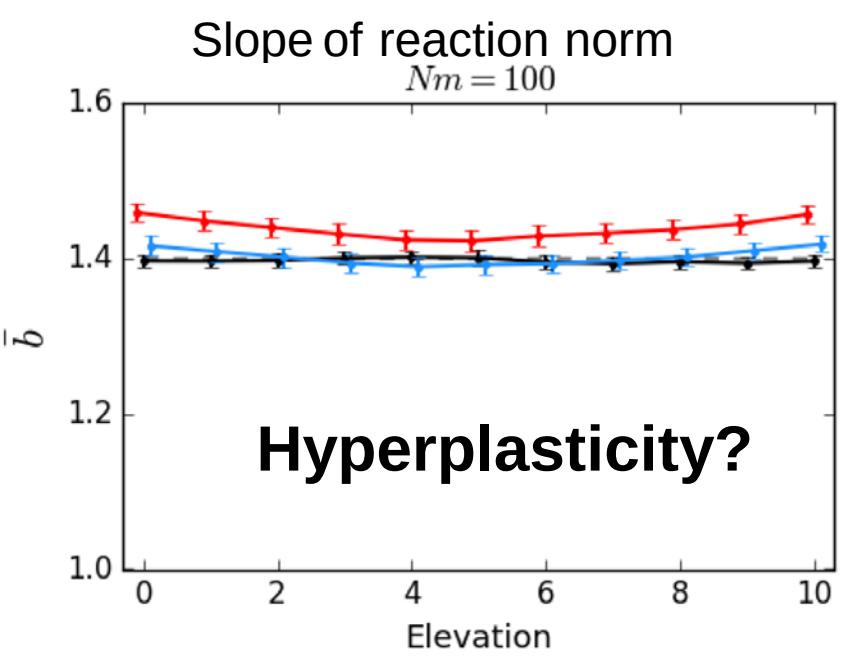


Cogradient variation

Slope shallower than optimal

Simulations with short distance gene flow





Cogradient variation

Slope steeper than optimal

Does assortative mating constrain the evolution of plasticity?

Fanny Laugier

Jean-Paul Soularue

Cyril Firmat

Antoine Kremer

AGENCE NATIONALE DE LA RECHERCHE ANR

PETER WALL INSTITUTE FOR ADVANCED STUDIES THE UNIVERSITY OF BRITISH COLUMBIA VANCOUVER

cnrs

Soularue et al. in revision

Can assortative mating accelerate evolution in a changing climate?

Claire Godineau

Céline Devaux

Godineau *et al.* 2021 Journal of Evolutionary Biology