Global models of herbivory variability: data from the HerbVar project

Kévin Tougeron, The Herbivory Variability Network

UMONS University of Mons

Écologie des Interactions EICG Changements Globaux

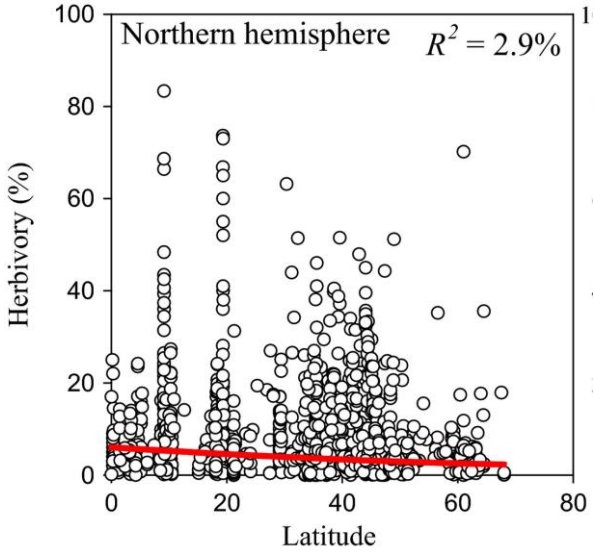
Royal Belgian Zoological Society

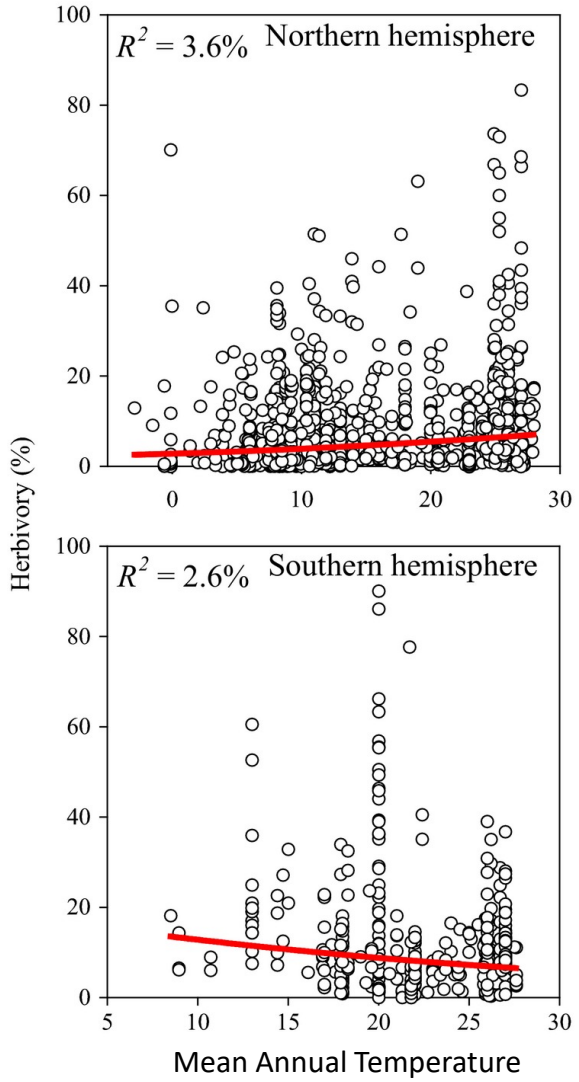
Benelux Zoology Congress 2024




Plant-herbivore interactions

Studies of the latitudinal gradient in herbivory all focus on variation **in mean herbivory**





Zhang et al., 2016

Variability in ecology

Disease ecology: Variability in pathogen transmission drives outbreak dynamics
Population ecology: Variability in local densities determine regional dynamics
Community ecology: Variability in traits alter interspecific interactions and eco-evo dynamics

Herbivory is highly variable

Disease ecology: Variability in pathogen transmission drives outbreak dynamics
Population ecology: Variability in local densities determine regional dynamics
Community ecology: Variability in traits alter interspecific interactions and eco-evo dynamics

"Field naturalists frequently observe that the intensity of insect herbivory in a natural defoliation event is not spread uniformly over individual conspecific plants"

Dan Janzen, 1985

Herbivory is highly variable

Two valley oaks at the same site

1000s of gall wasp galls

Zero gall wasp galls

Herbivory is highly variable

Low variability

High variability

Why is herbivory distributed homogenously here and variably here?

How variable is herbivory?

How does herbivory vary:

_ with plant traits?

_ geographically?

_ with various other factors?

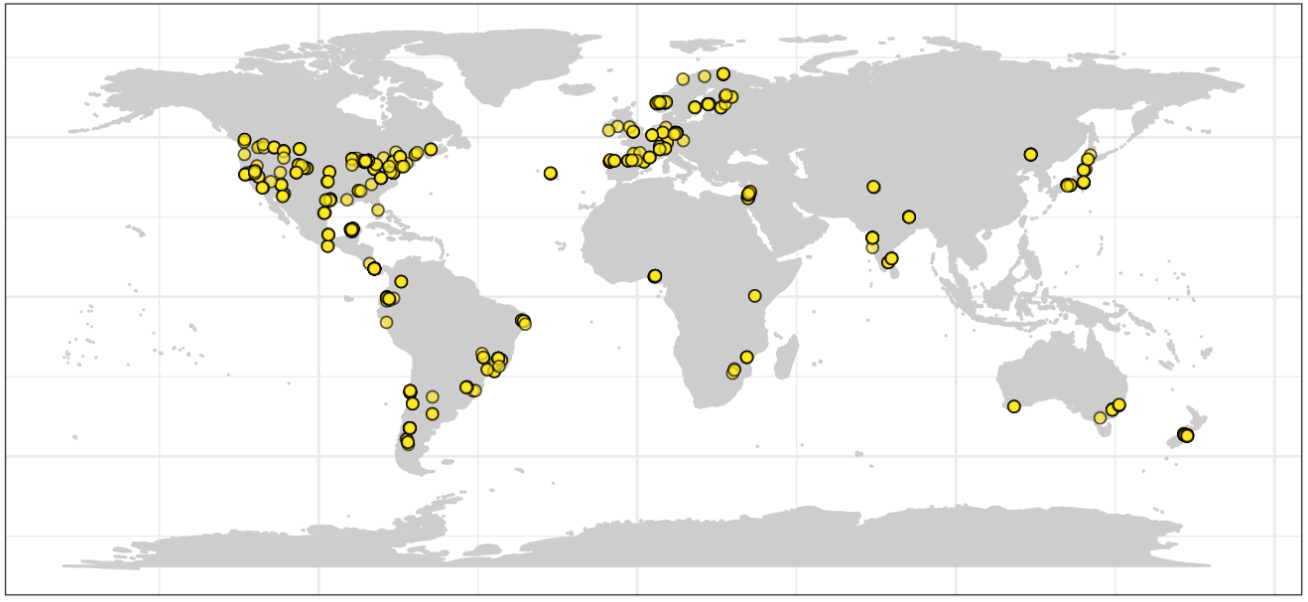
HerbVar: a global study of variability in plant-herbivore interactions

Will Wetzel
Michigan State University

Current dataset involves:

- 200+ collaborators
- 30+ countries
- 768+ surveys
- 492+ plant species
- 136+ families

Truly a global effort!



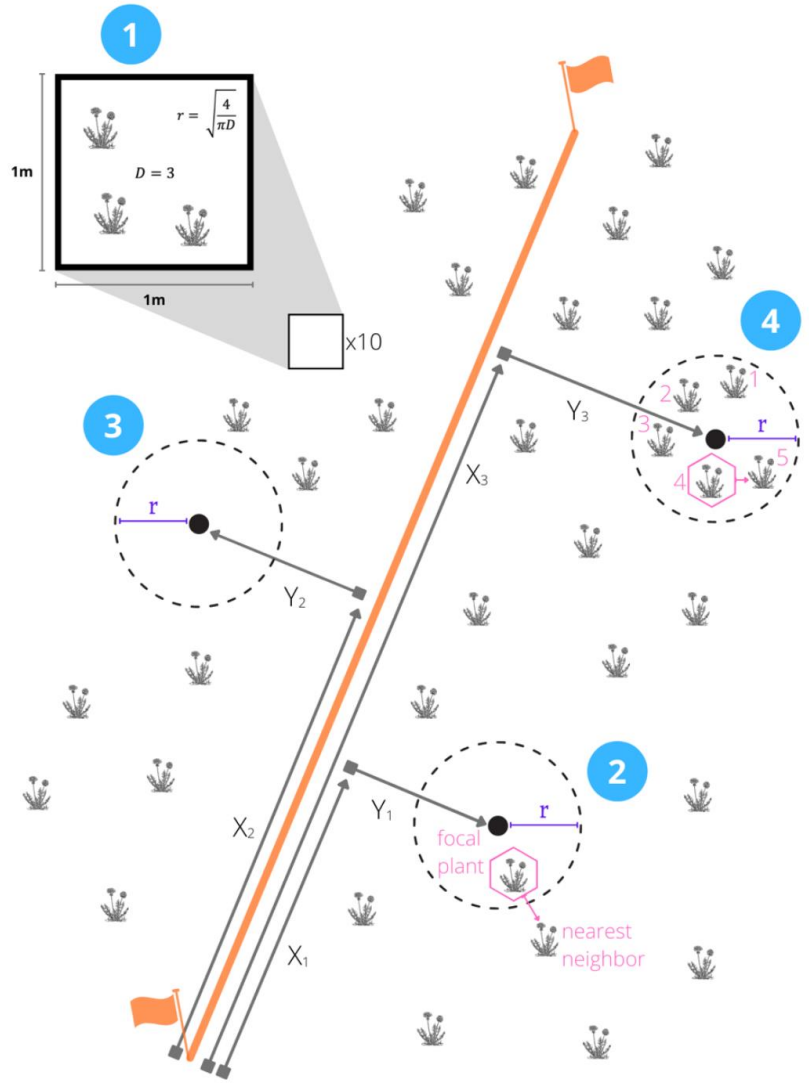
HerbVar: a global study of variability in plant-herbivore interactions

Spatially explicit surveys of:

- 30 focal plants
- 30 neighbors

Data includes:

- Whole plant herbivory level
- % damage to 10+ leaves per plant
- Plant size
- Plant density
- Lots of site and species data



Metric of variability

The Gini index

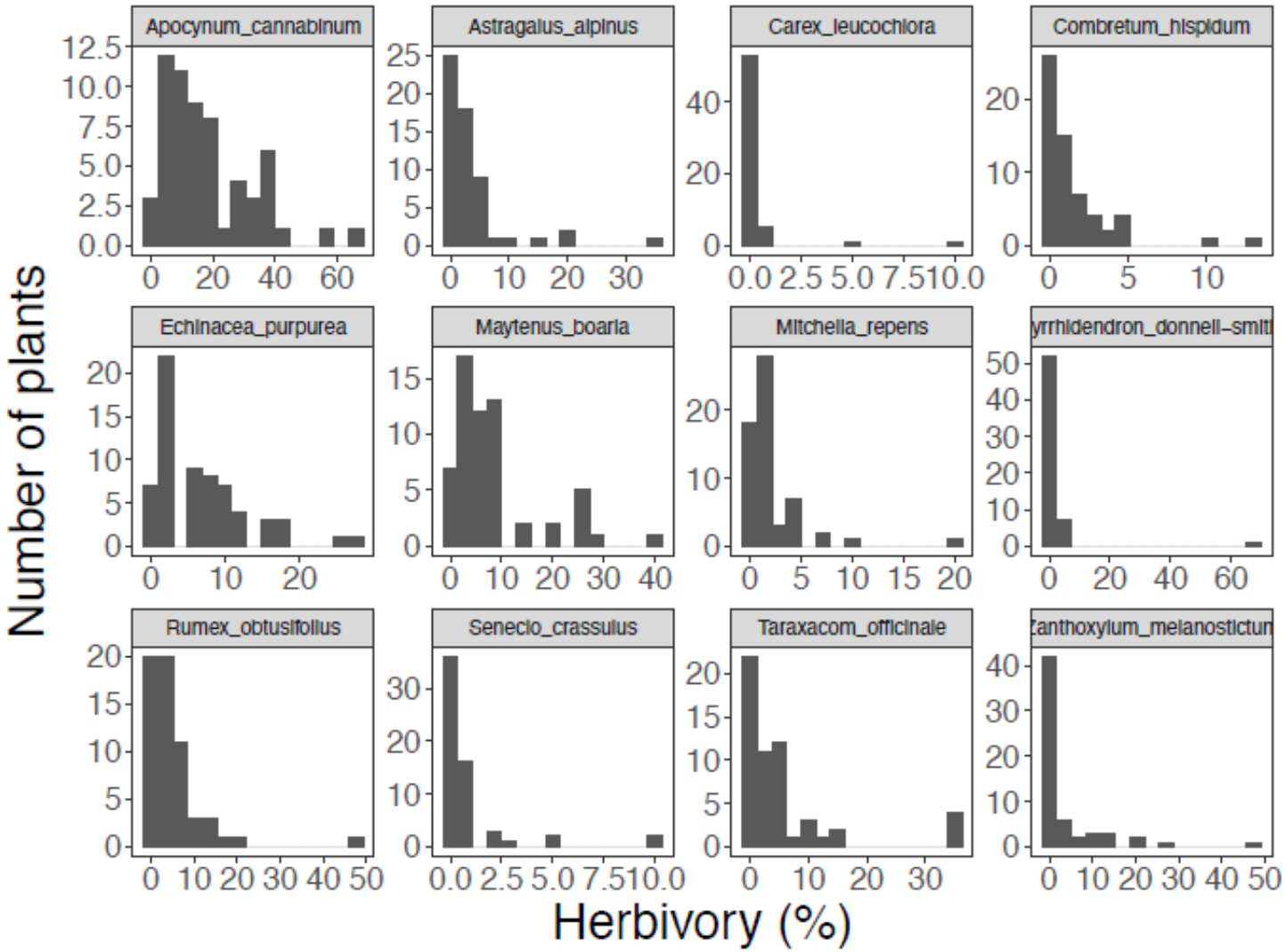
$$Gini = 1 - \sum_j p_j^2$$

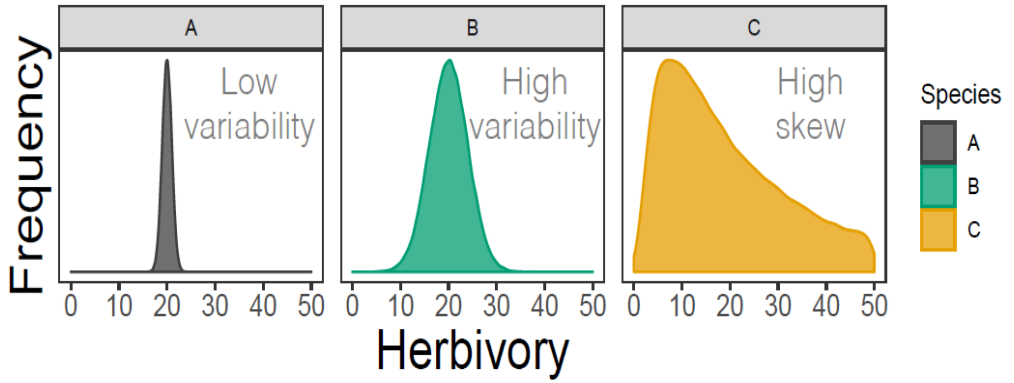
- Metric of the inequality of a distribution
- 0 = even, 1 = uneven
- Normalizes by total herbivory

Gini = 0

Gini = 1.0

Main results
1. Herbivory is variable and the variability varies!



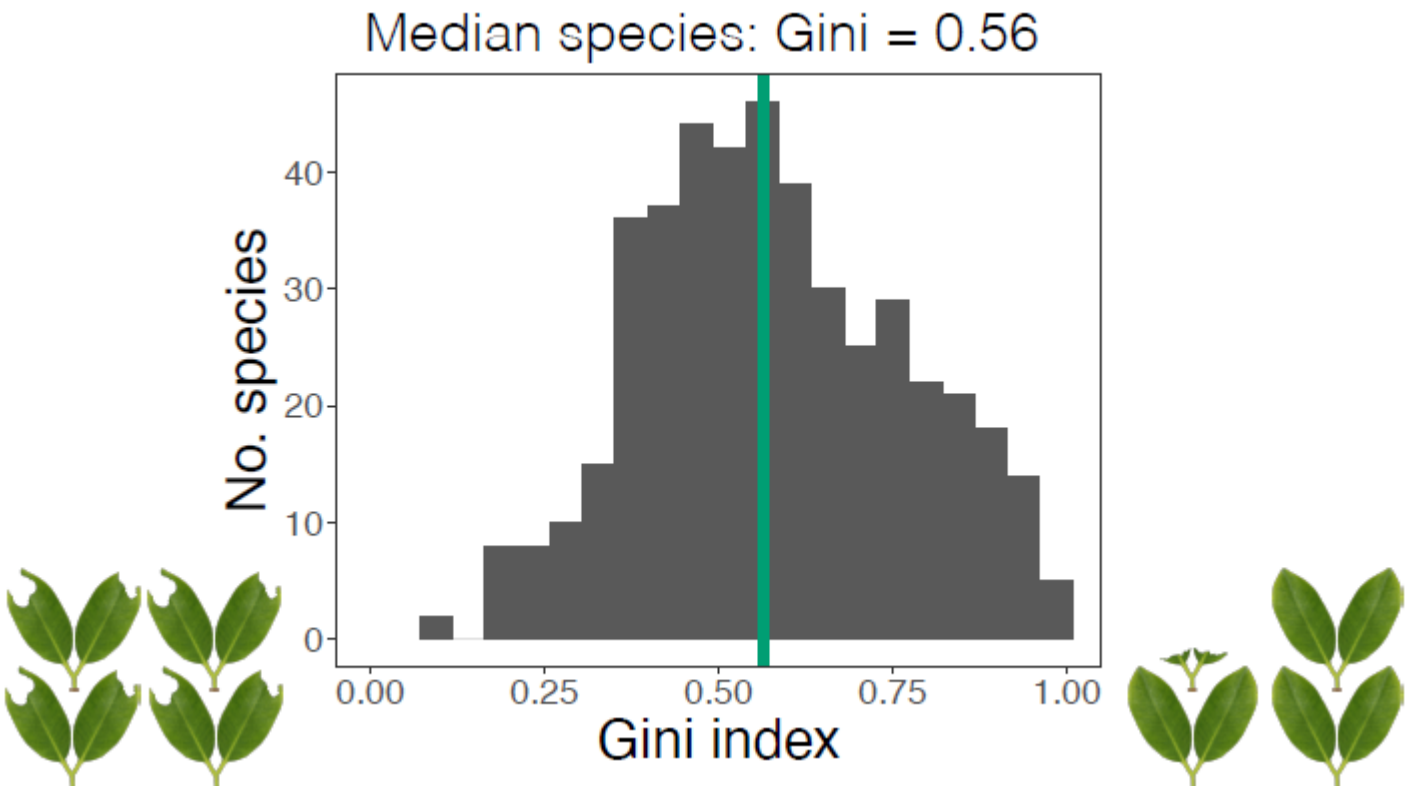


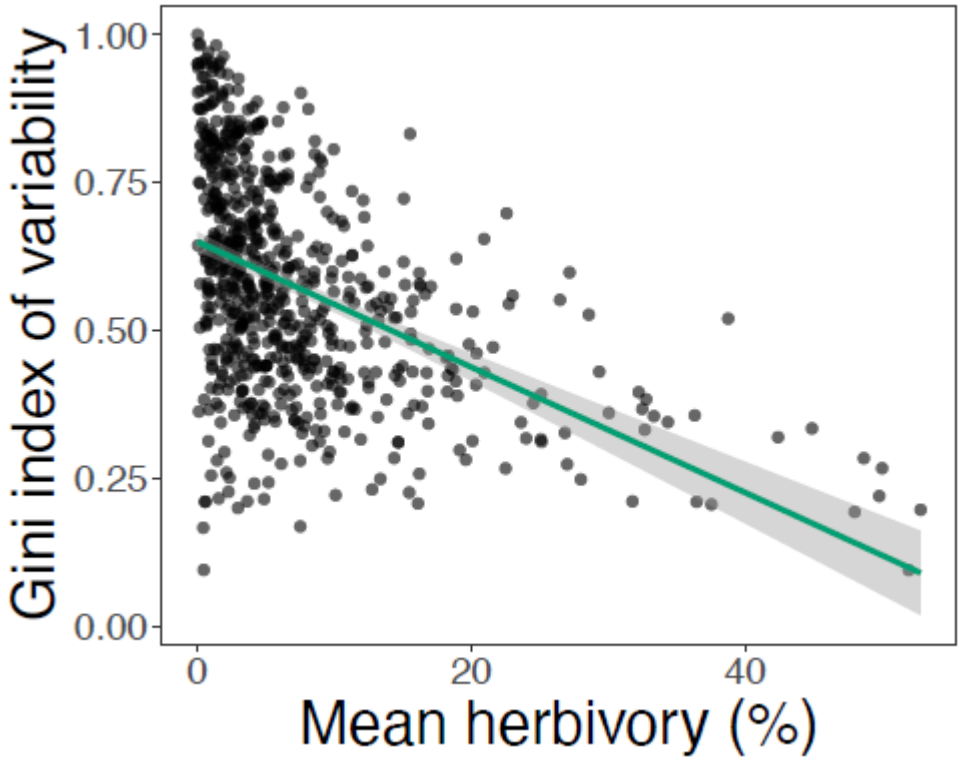
Treat variability, or the spread & shape of statistical distributions, as potentially **important**

Study it as a **response** or predictor variable and quantify how it varies

An alternative to mean-centric ecology is **variability-explicit ecology**

Main results
1. Herbivory is variable and the variability varies!

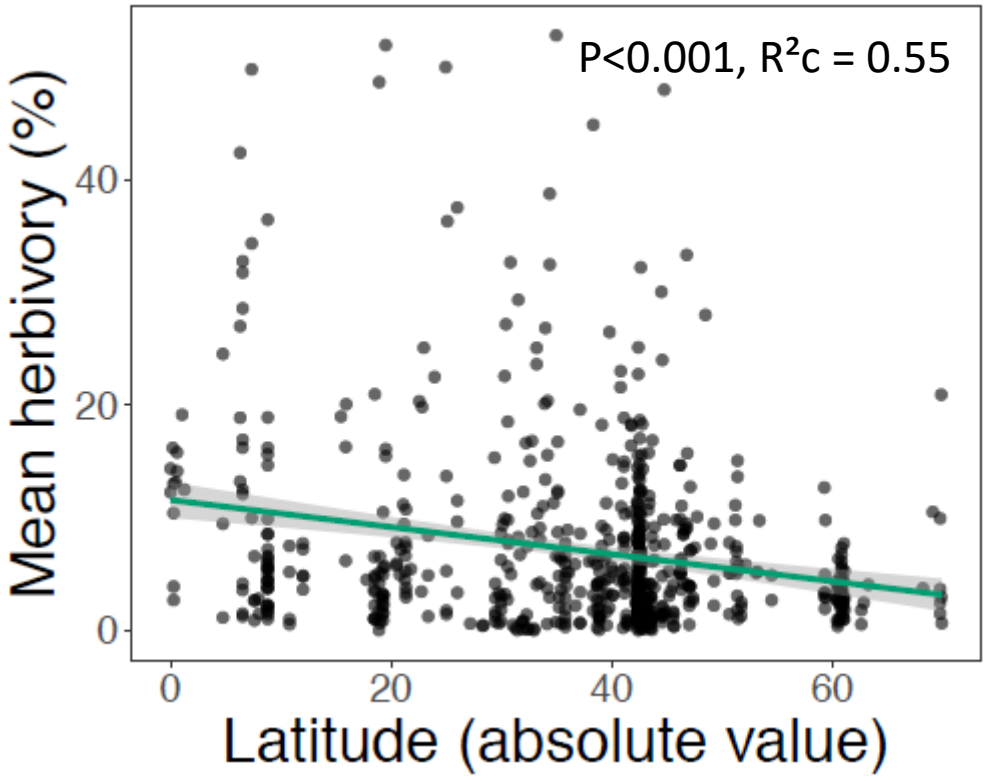


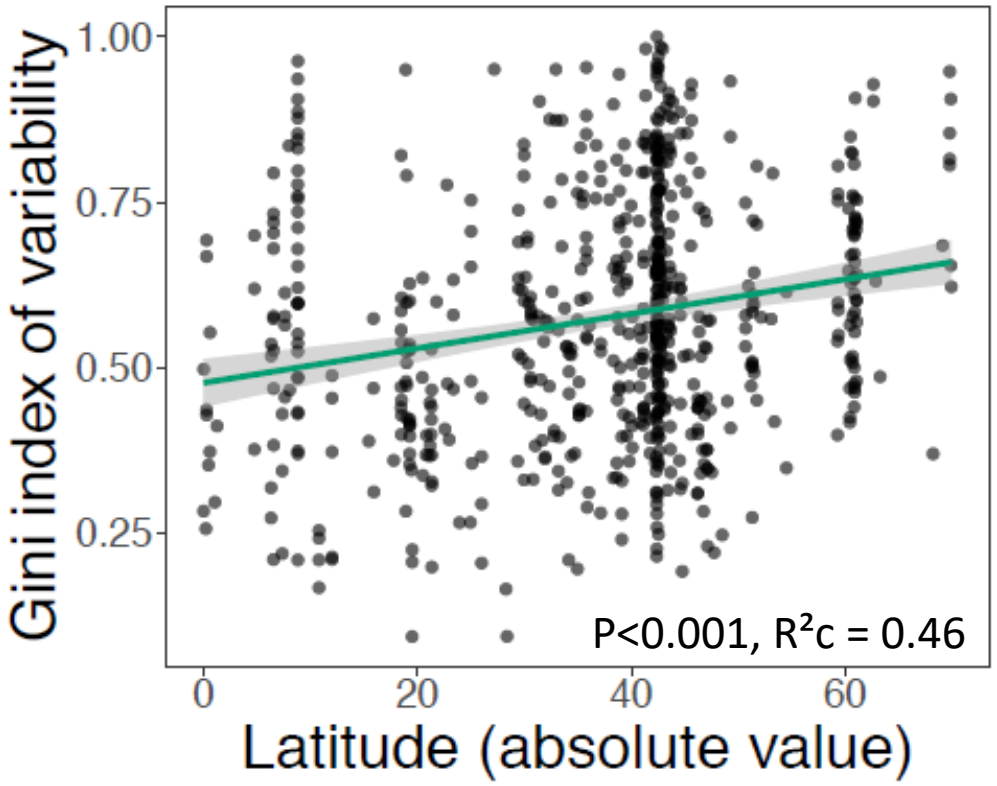


A population in which 10% of plants get 50% of all herbivore damage corresponds to a Gini value of 0.5

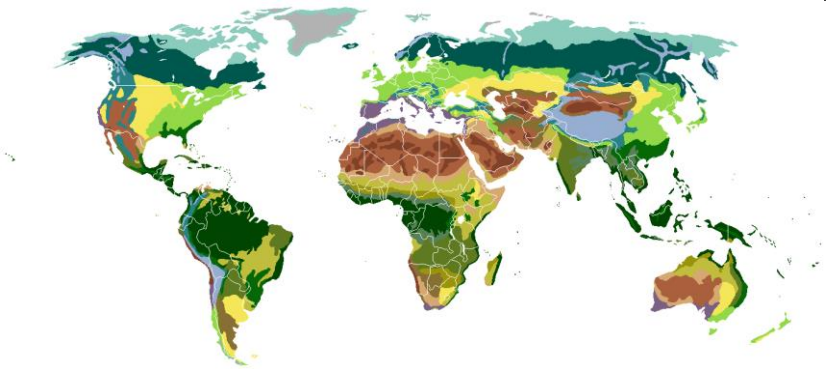
Between individuals, within species

Main results
2. Herbivory variability varies strongly with latitude

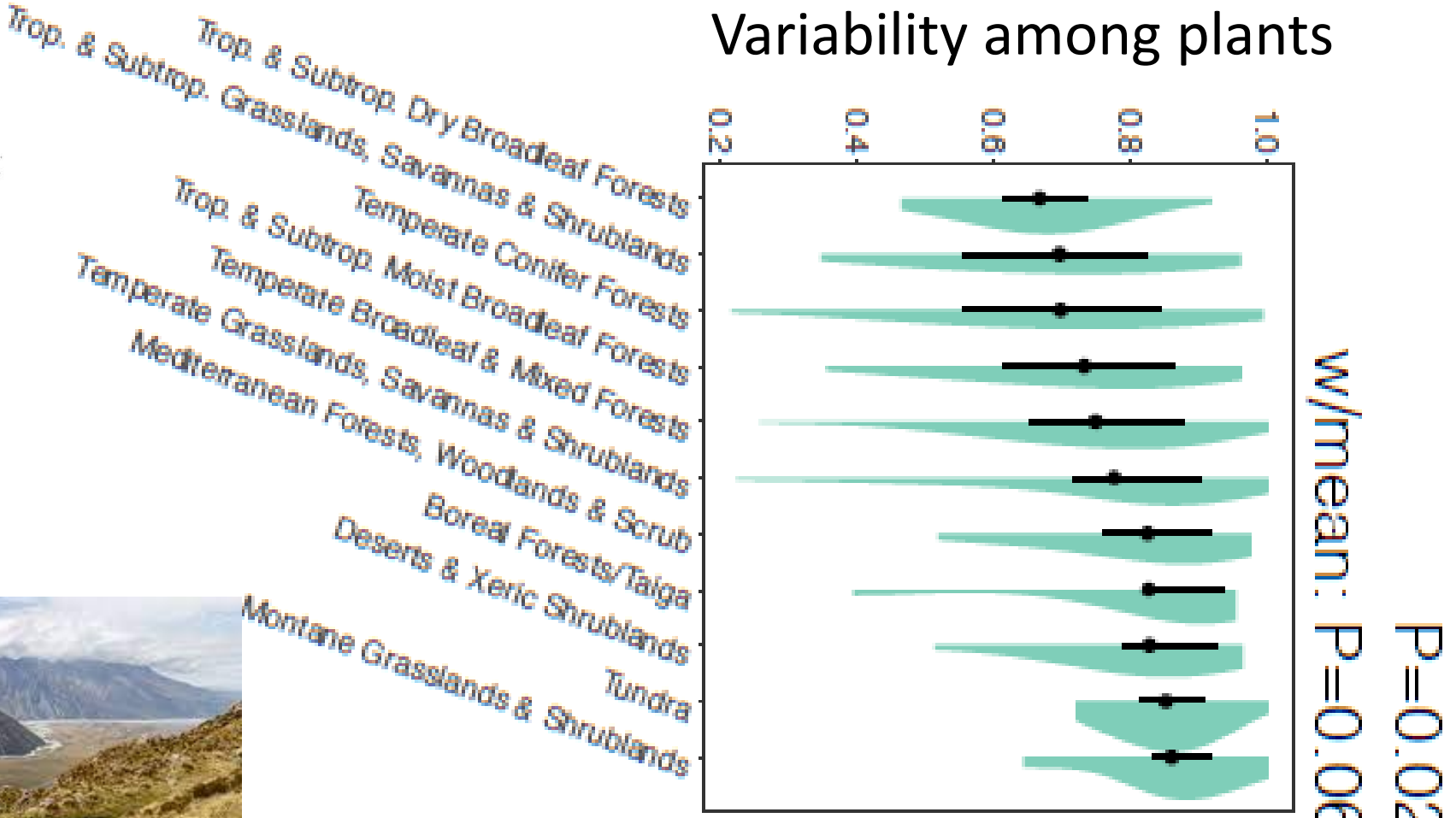




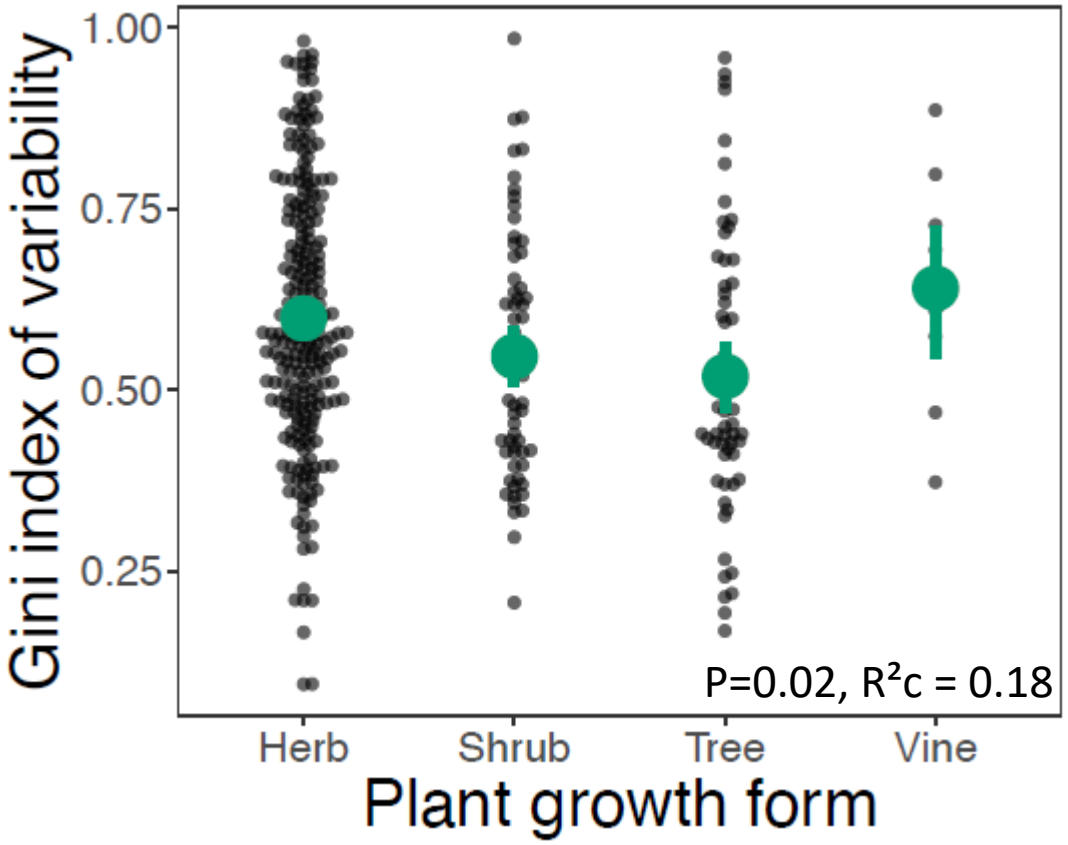
Main results
3. Herbivory variability varies across biomes

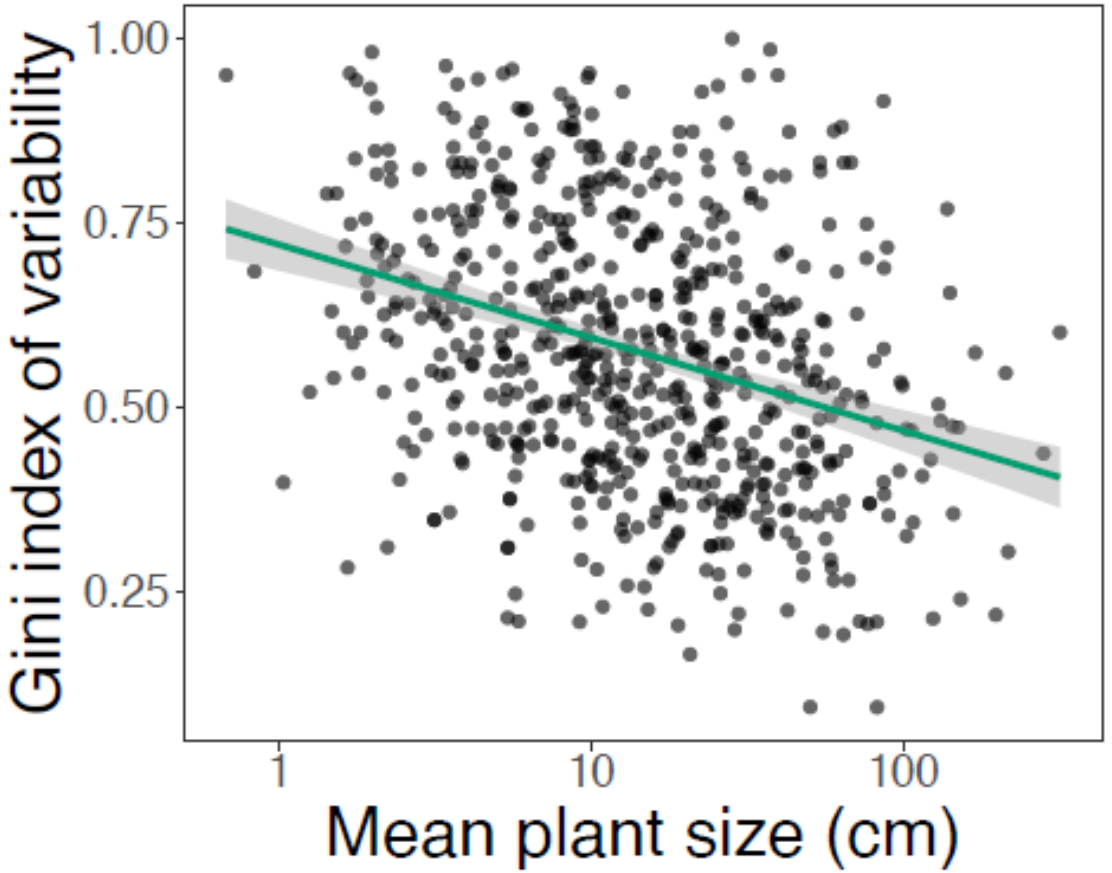


Variability among plants



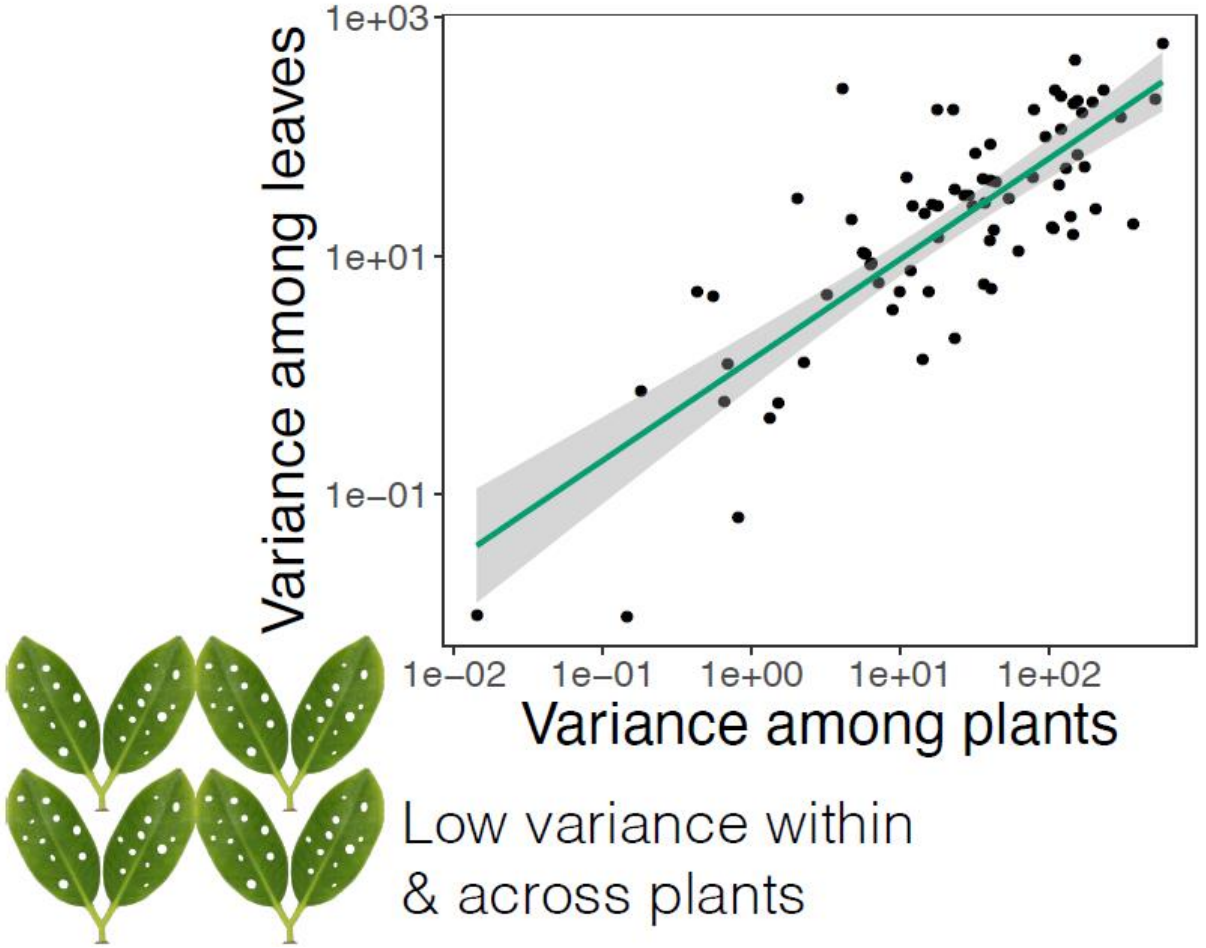
Main results
4. Herbivory variability varies depending on plant traits





Main results
4. Herbivory variability varies depending on plant traits

Variability transcends scales within and among plants

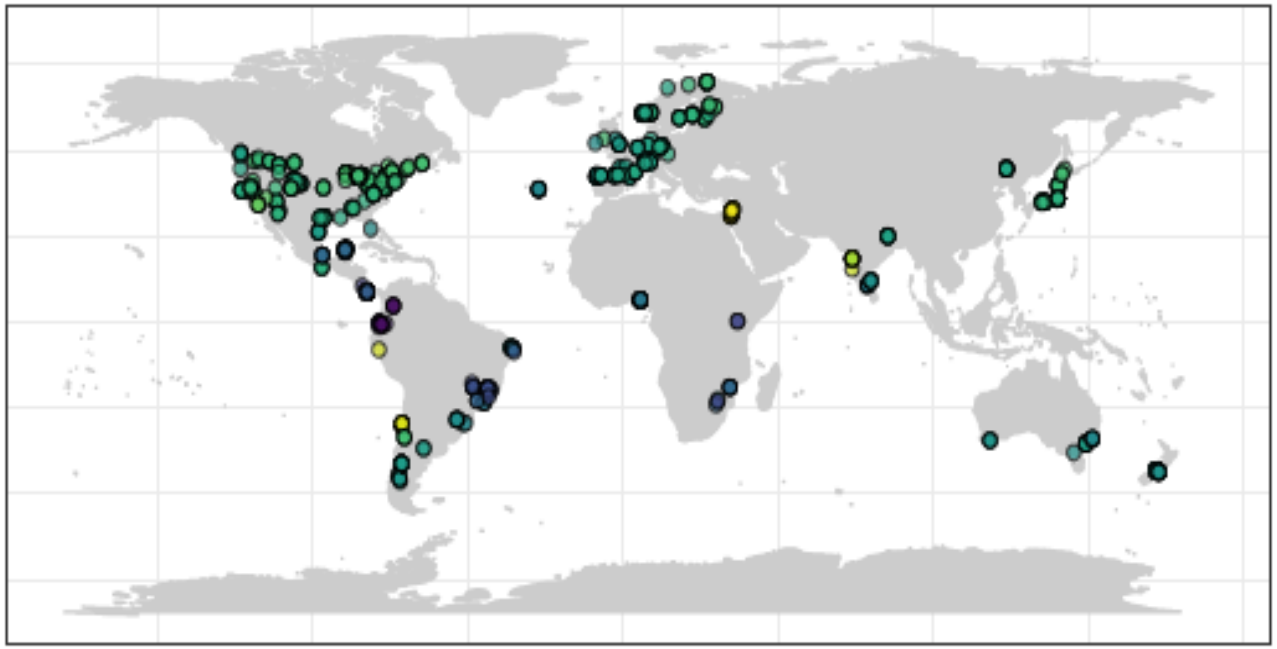


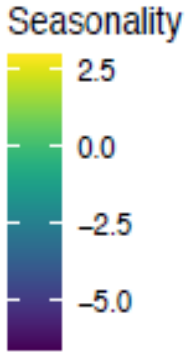
High variance within & across plants

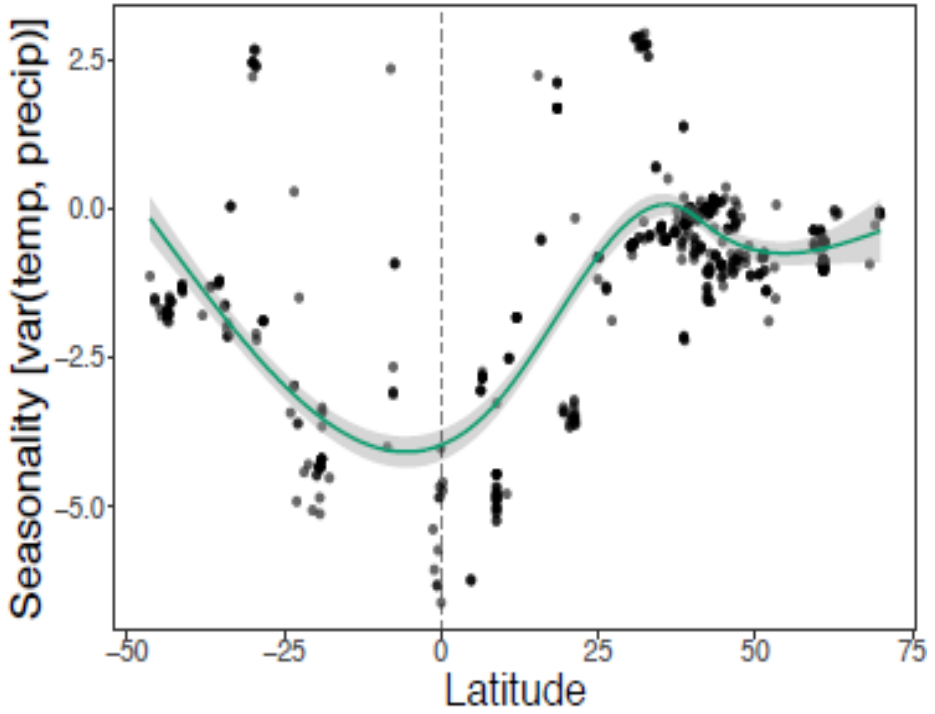
Low variance within & across plants

$P < 0.001$, $R^2 = 0.65$

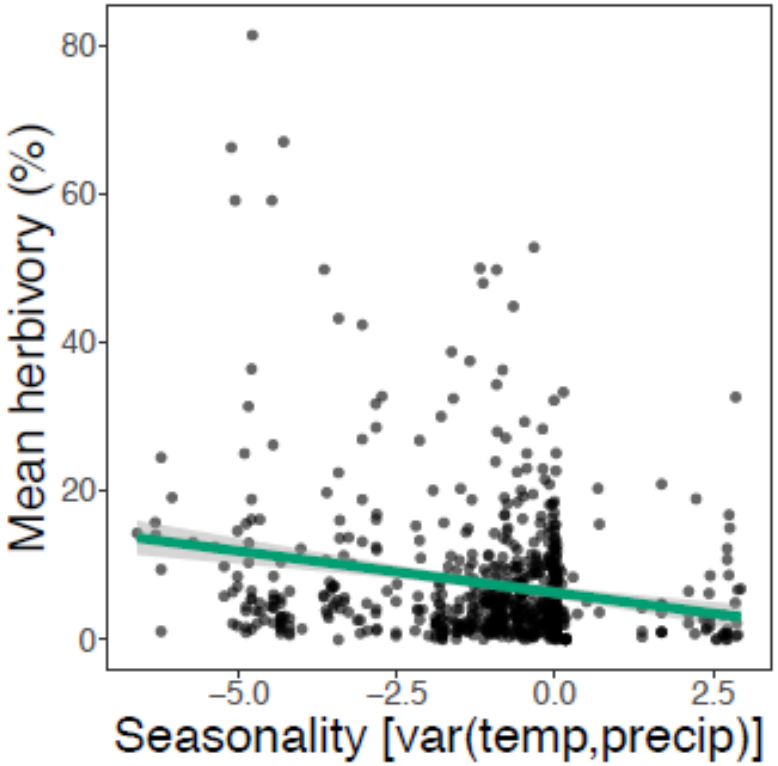
Main results
5. Herbivory variability varies with seasonality



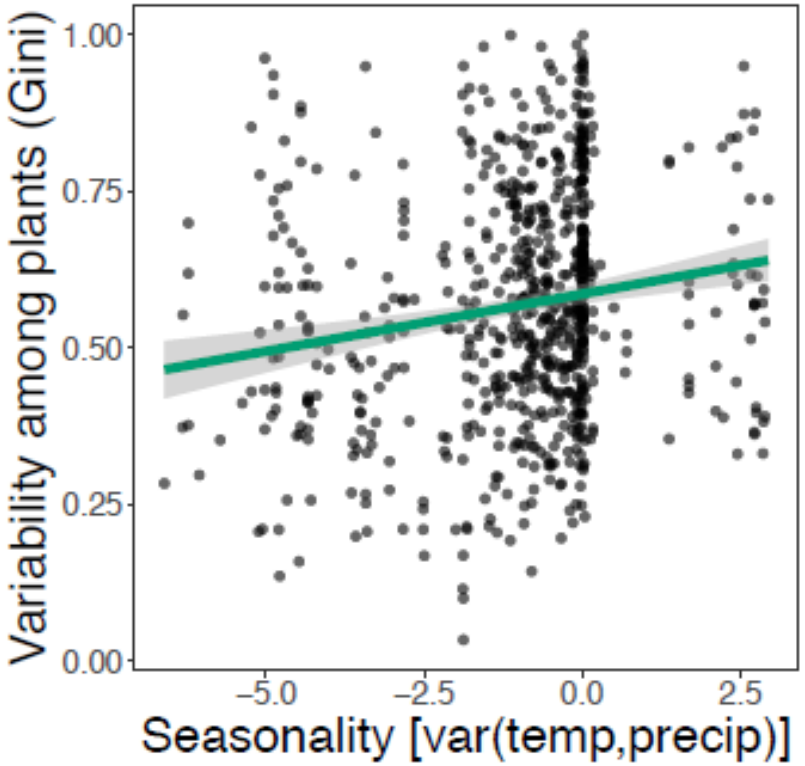




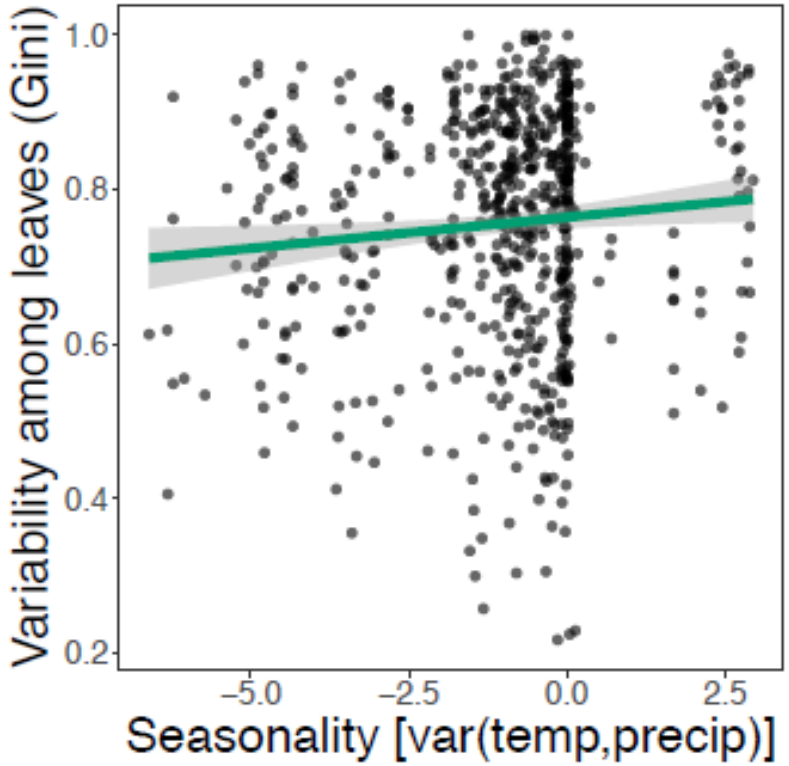
Main results
5. Herbivory variability varies with seasonality



P<0.01



bivariate: P<0.01
w/ mean as covariate: P=0.34



bivariate: P=0.19
w/ mean as covariate: 0.48

Take-home message

- Variability has **major macroecological** and **macroevolutionary patterns** that differ from mean patterns
- Latitude, biomes, plant-size, seasonality or phylogeny play an important role in **shaping plant-herbivore interaction variability**
- Variability is an **integral feature** of plant-herbivore Interactions; how we think about **ecology & evolution**

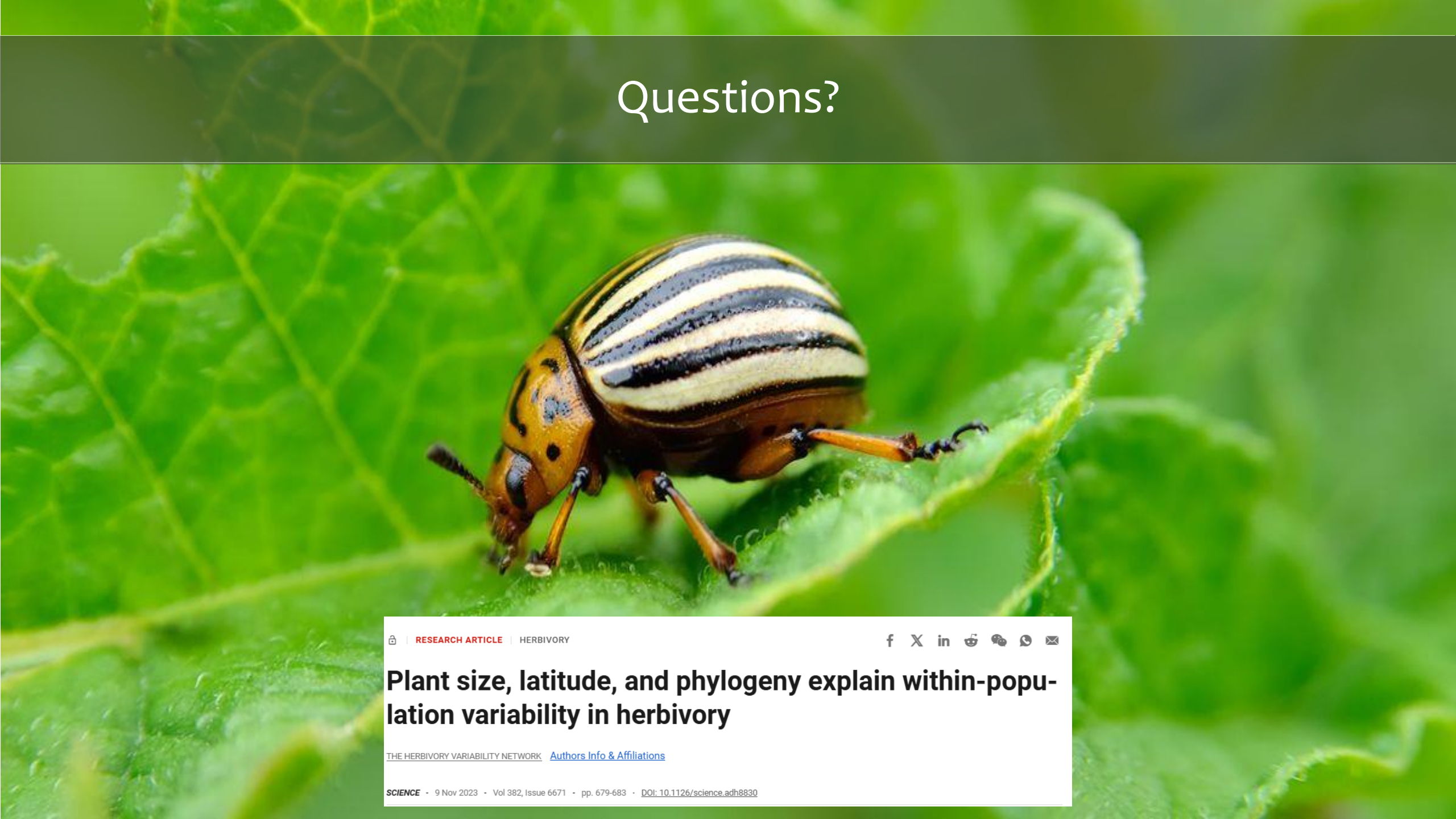
Goal for Phase 2: Understand variability in damage to reproductive tissues

Abronia umbellata
Photo: Eric LoPresti

Monarda fistulosa
Photo: Phil Hahn

Lonicera x *bella*
Photo: Susan Whitehead

Questions?



RESEARCH ARTICLE | HERBIVORY

Plant size, latitude, and phylogeny explain within-population variability in herbivory

THE HERBIVORY VARIABILITY NETWORK Authors Info & Affiliations

SCIENCE · 9 Nov 2023 · Vol 382, Issue 6671 · pp. 679-683 · DOI: 10.1126/science.adh8830