

Intertwining of fecundity, sexual and viability selection on spring phenology along an altitudinal gradient of European beech



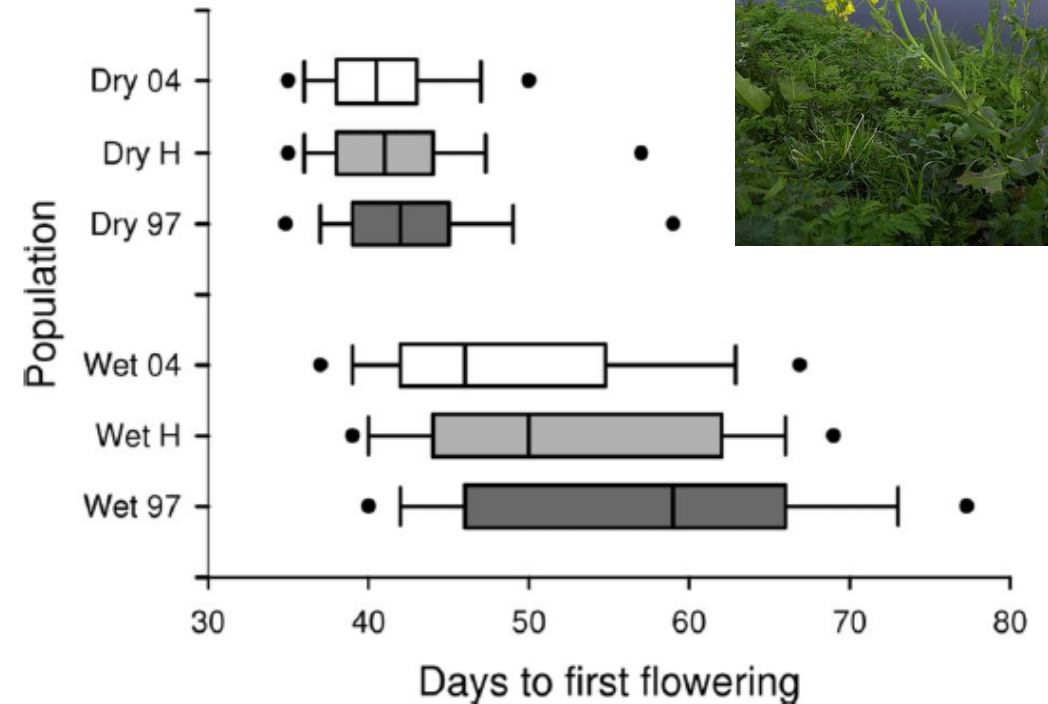
Avignon, 22/06/2022

Sylvie Oddou-Muratorio, Julie Gauzere,
Francois Lefèvre, Etienne Klein

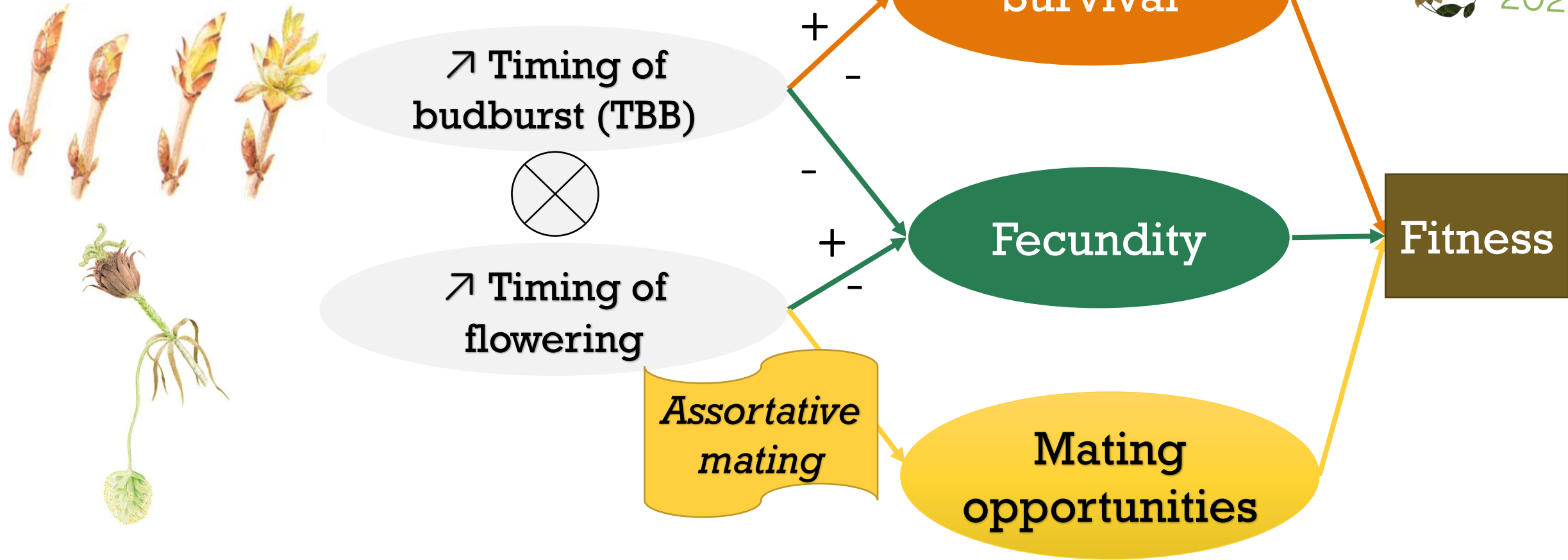
Phenology, a key trait for the genetic adaptation of populations to ongoing climate change



- Significant advance in leafing, flowering and fruiting records in temperate plants (Menzel et al. 2006)
- Evidence for rapid evolution of phenological traits in response to selection (Franks et al. 2007, Hamman et al. 2018)
- To what extent microevolution may contribute to the response of plants' populations to climatic variation (Merilä and Hendry 2014) ?

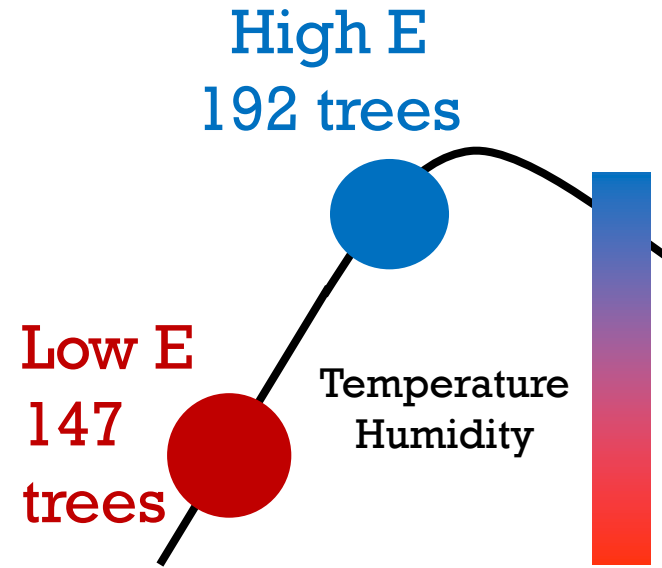
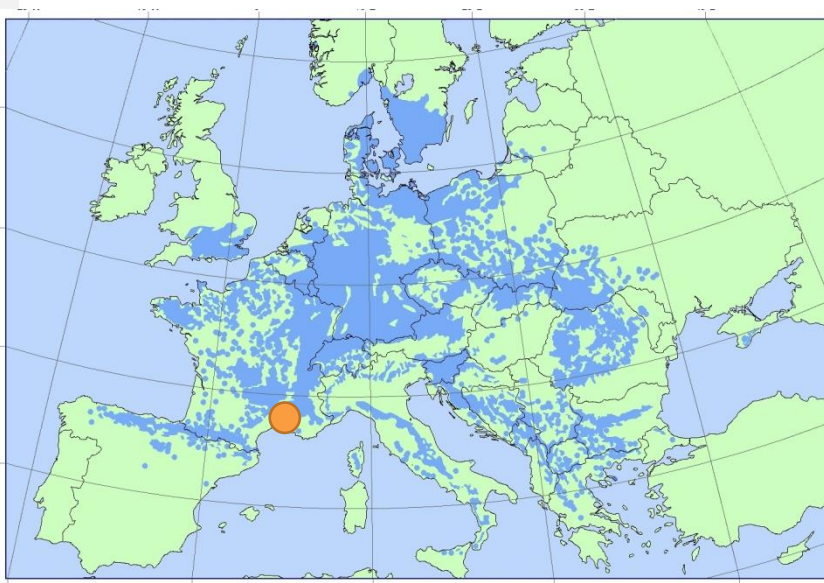


From phenology to fitness

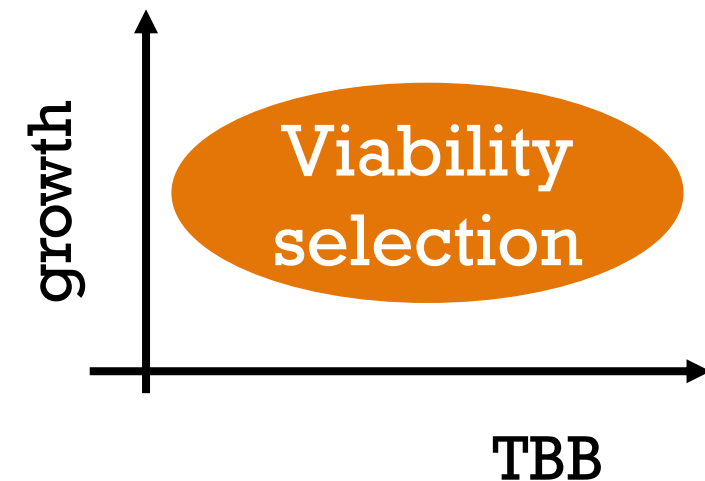
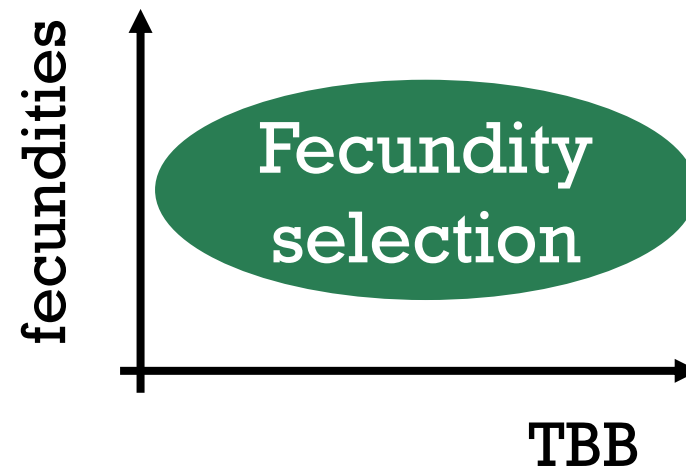
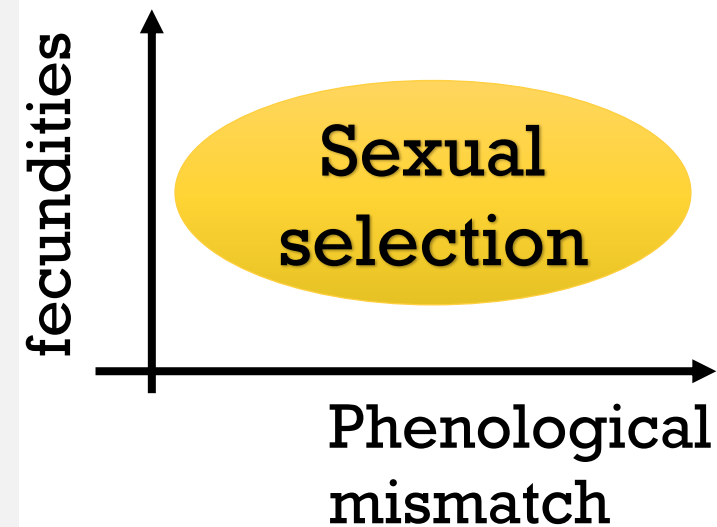


How can we disentangle/estimate the components of selection on beech spring phenology ?

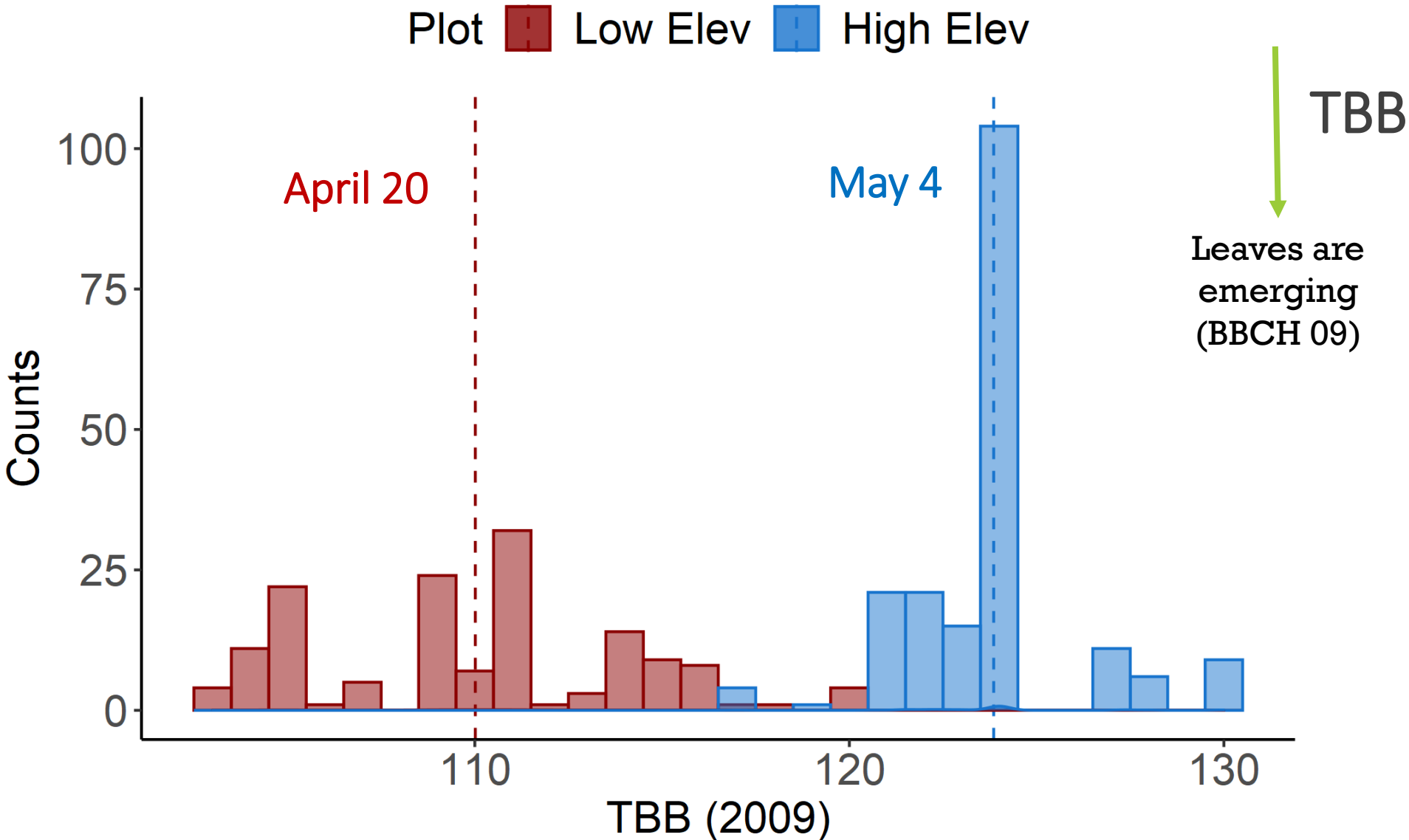
Material and methods: estimating selection *in situ* in the European beech (*Fagus sylvatica*)



- TBB < Phenological survey
- ♂ and ♀ female fecundities estimated through paternity and parentage analyses

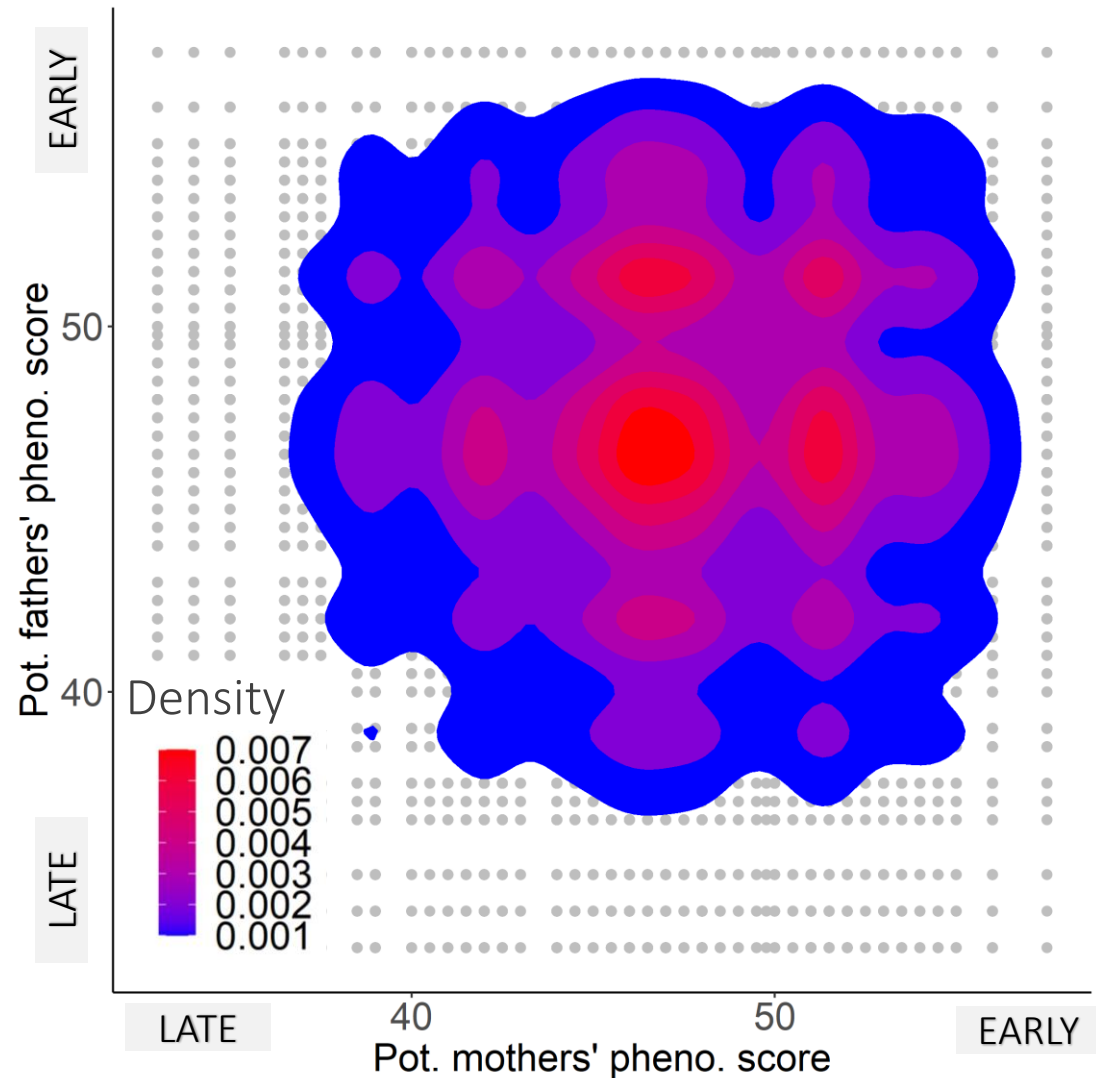


Distribution of TBB



Assortative mating

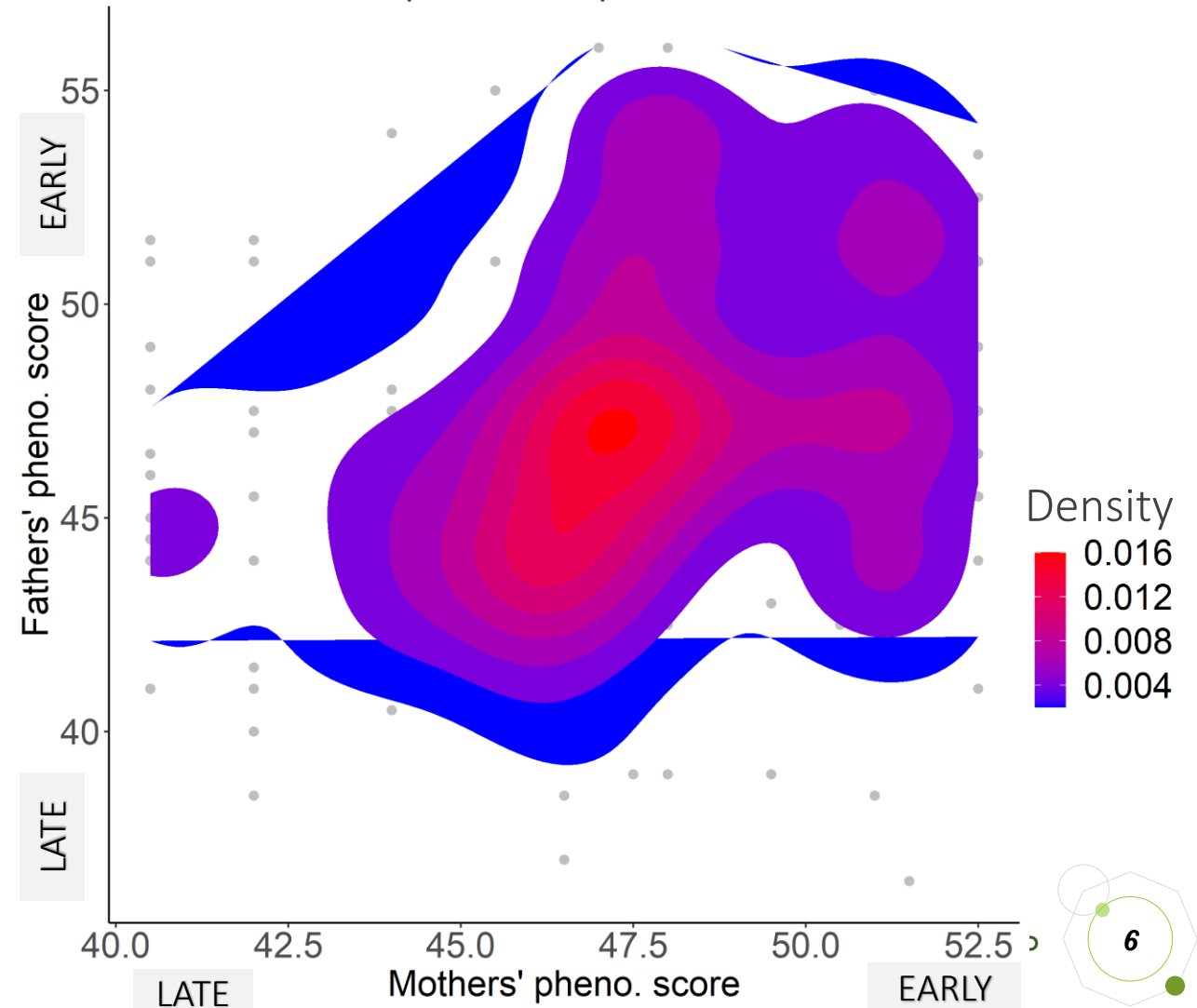
Random mating,
site low Elevation



Significant correlation between mother and
father's TBB at low elevation

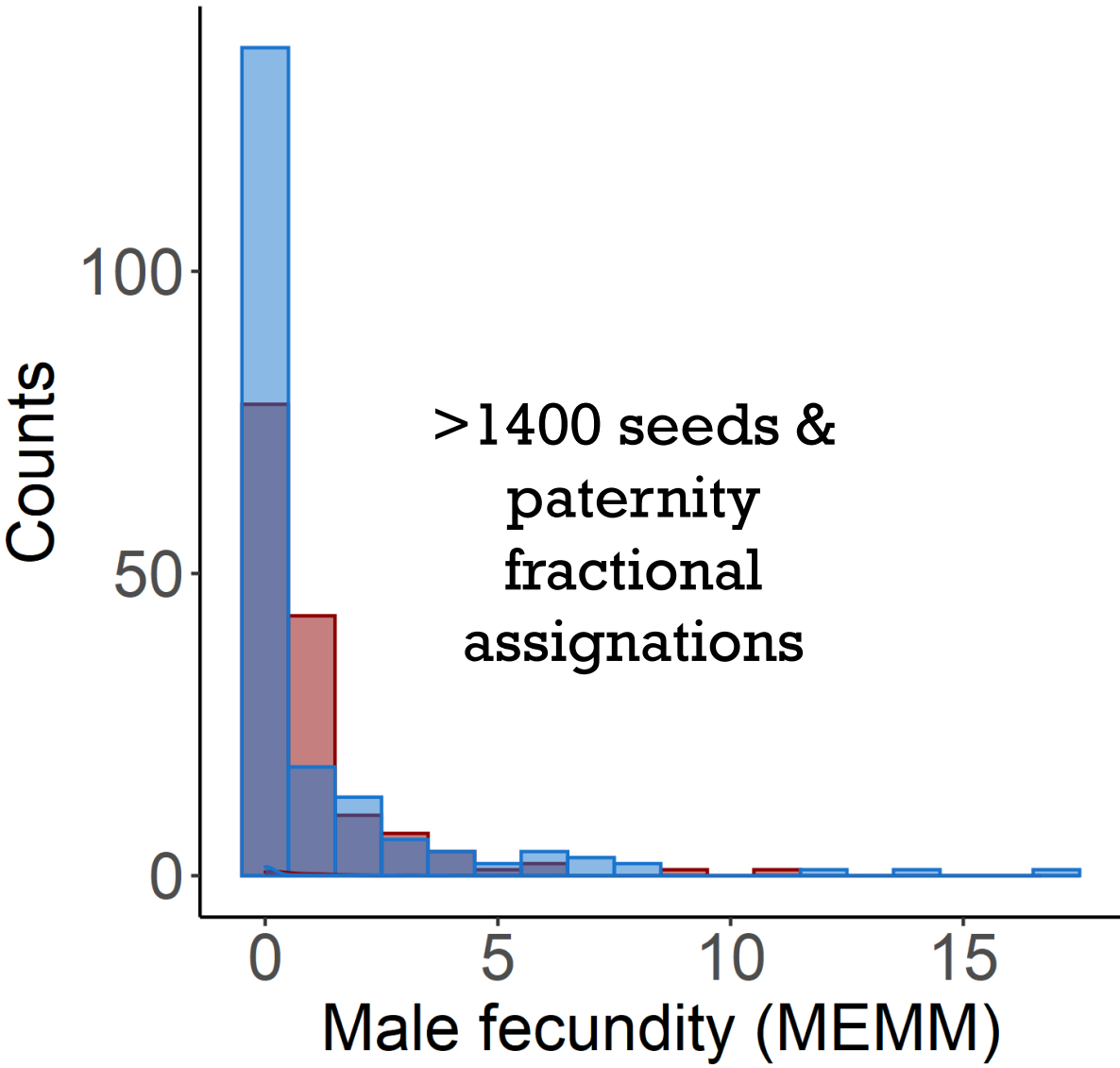
Realized mating

$\rho=0.19$, $p\text{-val}<0.001$

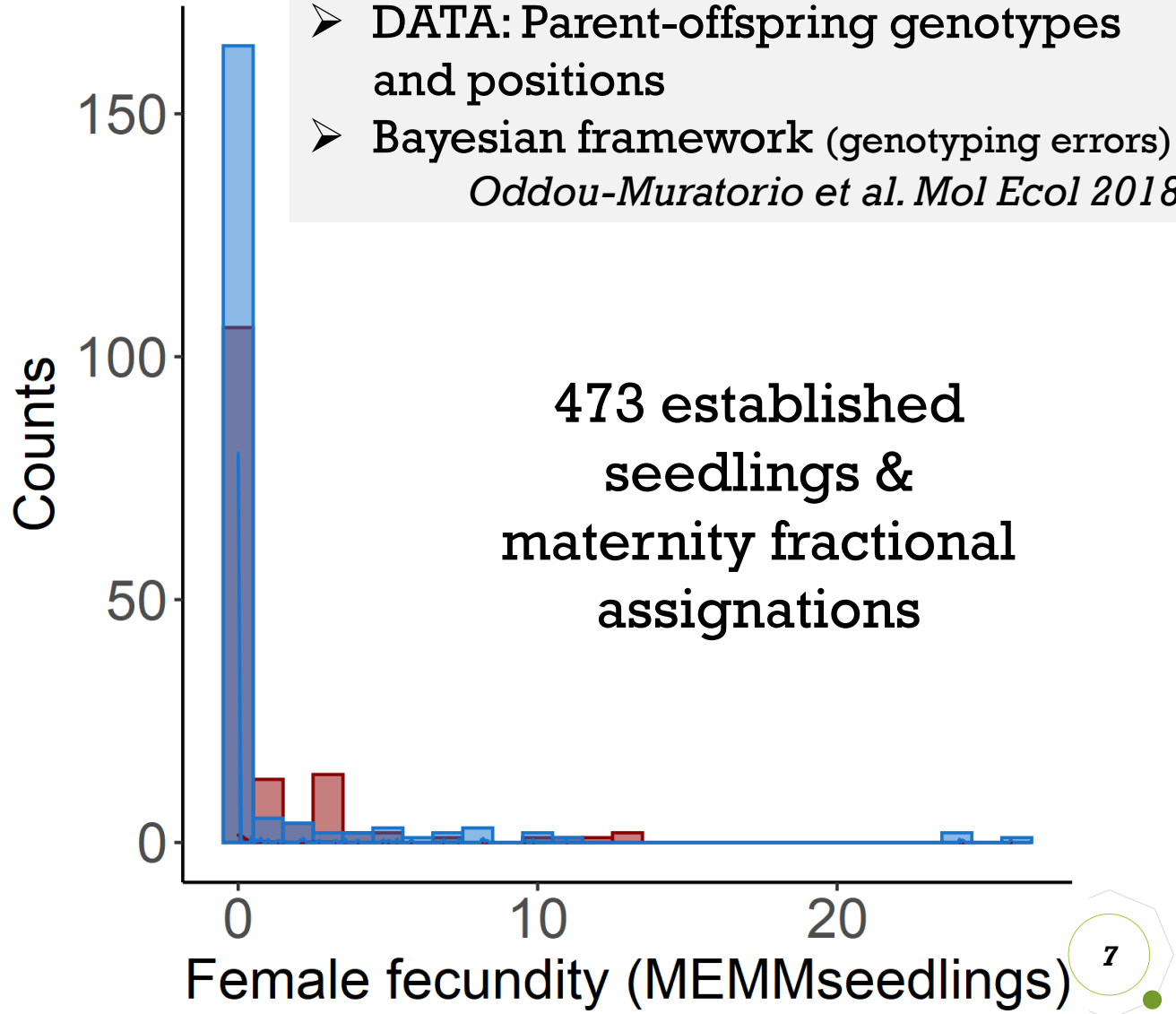


Distribution of ♂ and ♀ fecundities

Plot ■ Low Elev ■ High Elev

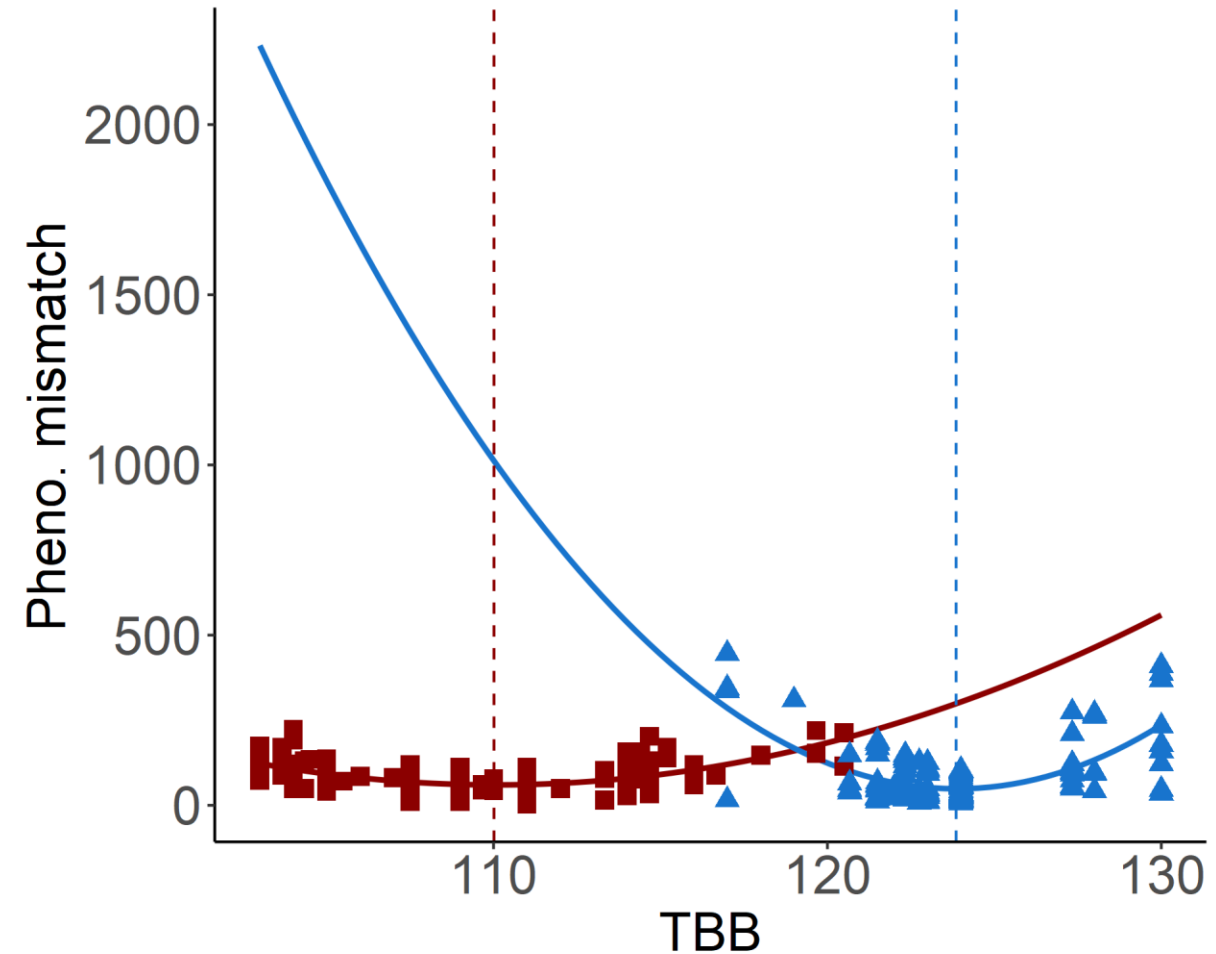
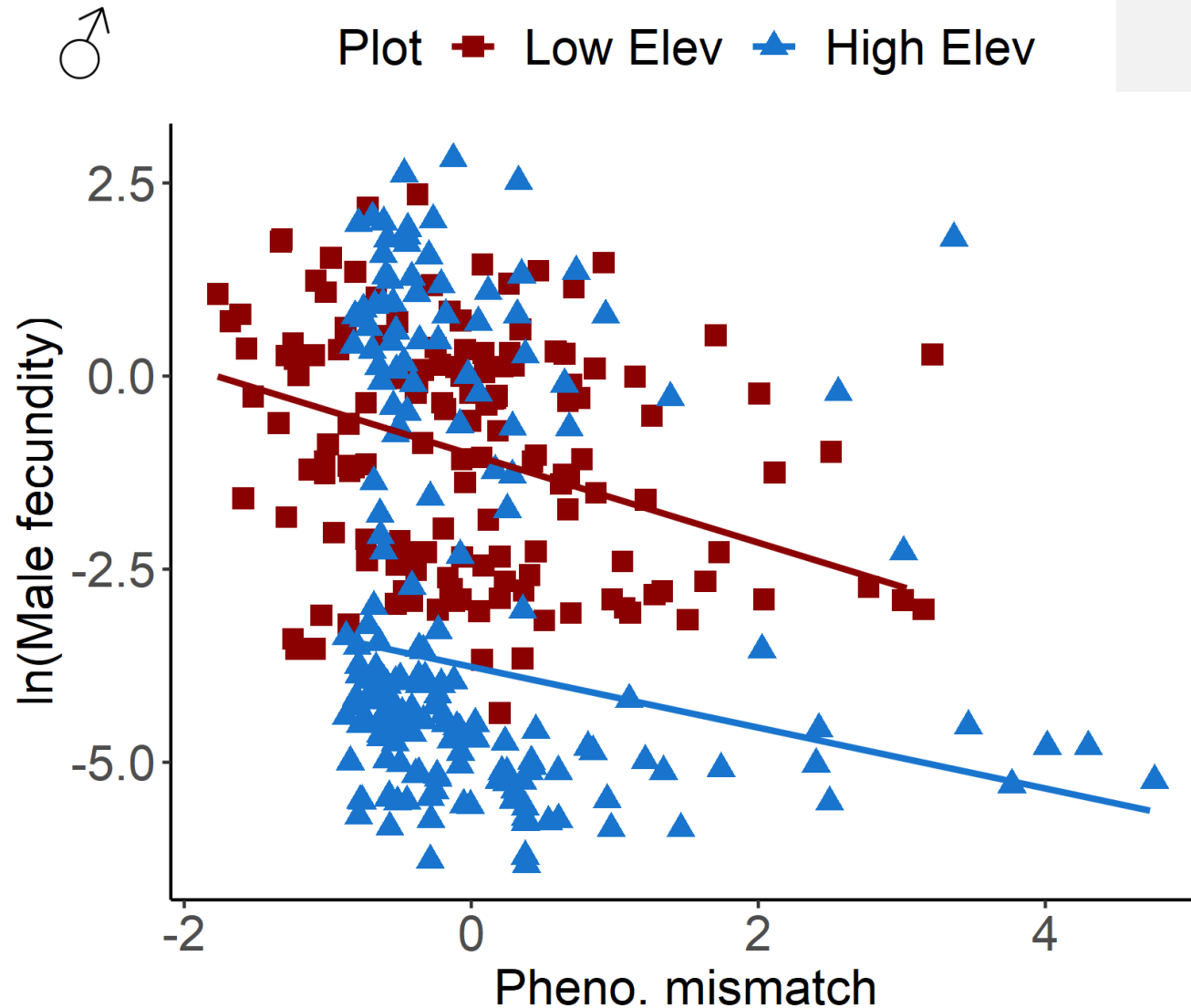


- MEMM & MEMMseedlings**
- Spatially Explicit Mating Model
 - Pollen (and seed) dispersal jointly with ♂ (and ♀) fecundities
 - DATA: Parent-offspring genotypes and positions
 - Bayesian framework (genotyping errors)
- Oddou-Muratorio et al. Mol Ecol 2018*



Sexual selection

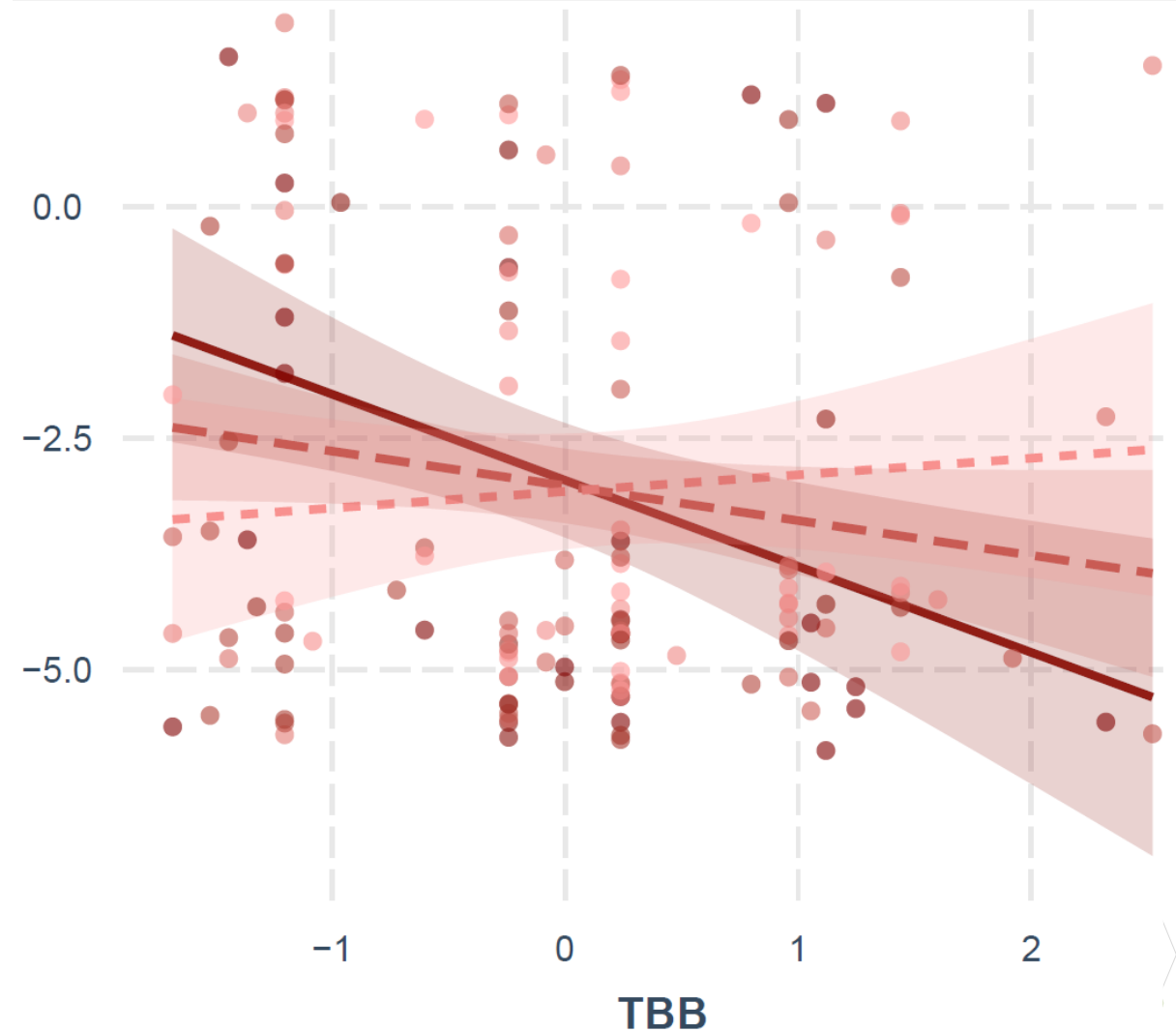
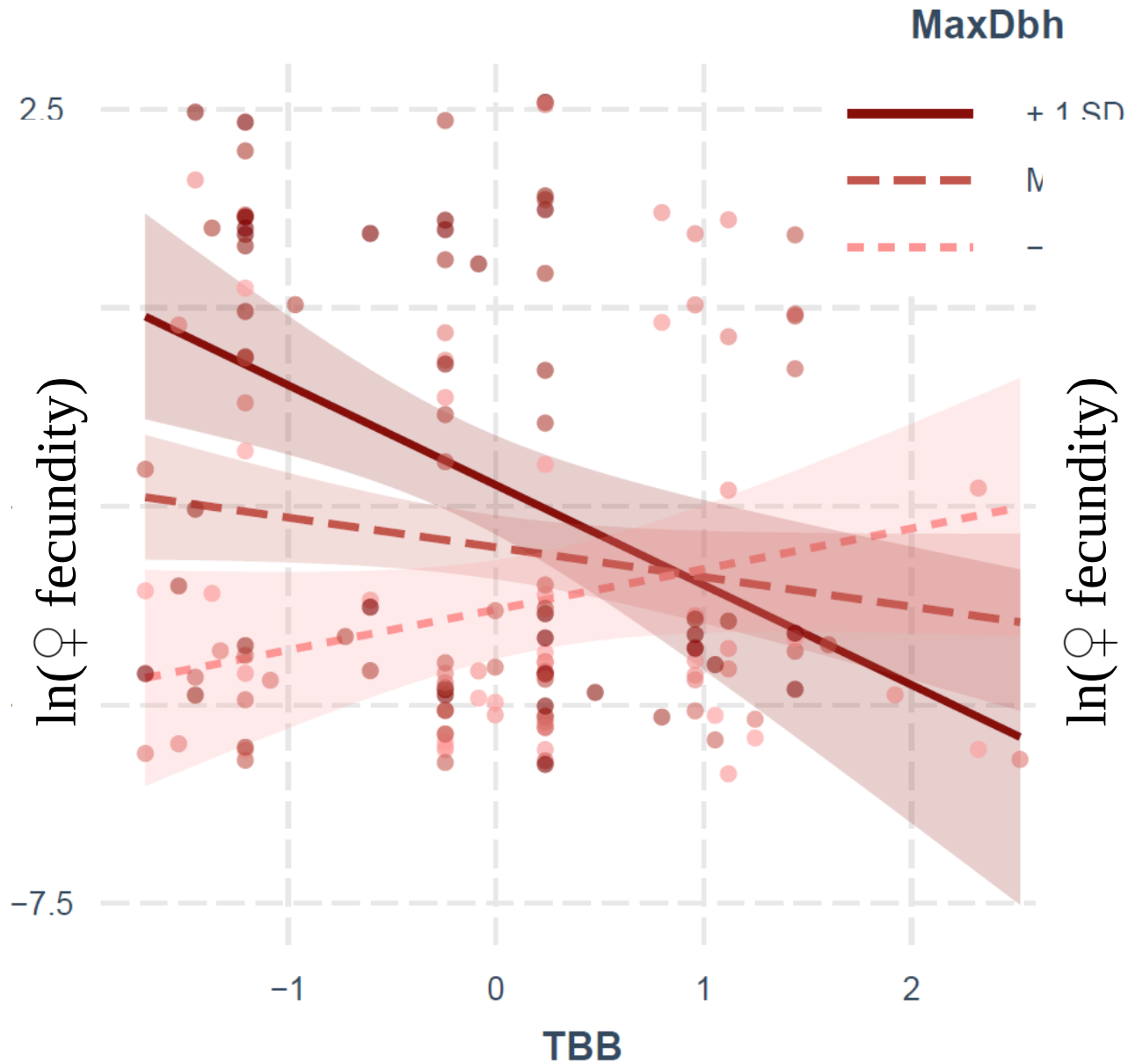
- ♂ fecundity decreased with increasing phenological mismatch at both plots
- ♀ fecundity was not affected by phenological mismatch



Fecundity selection

Low E

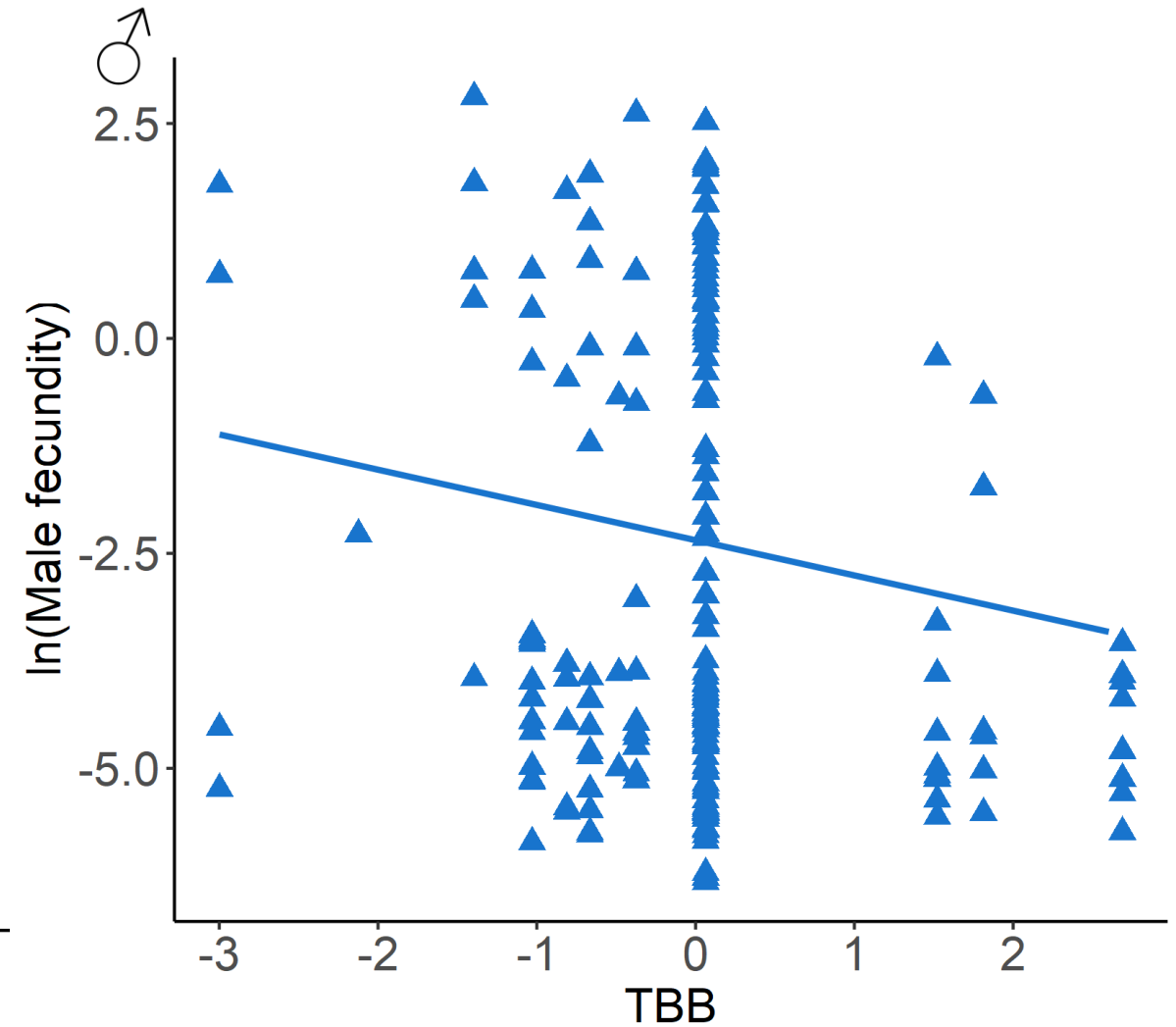
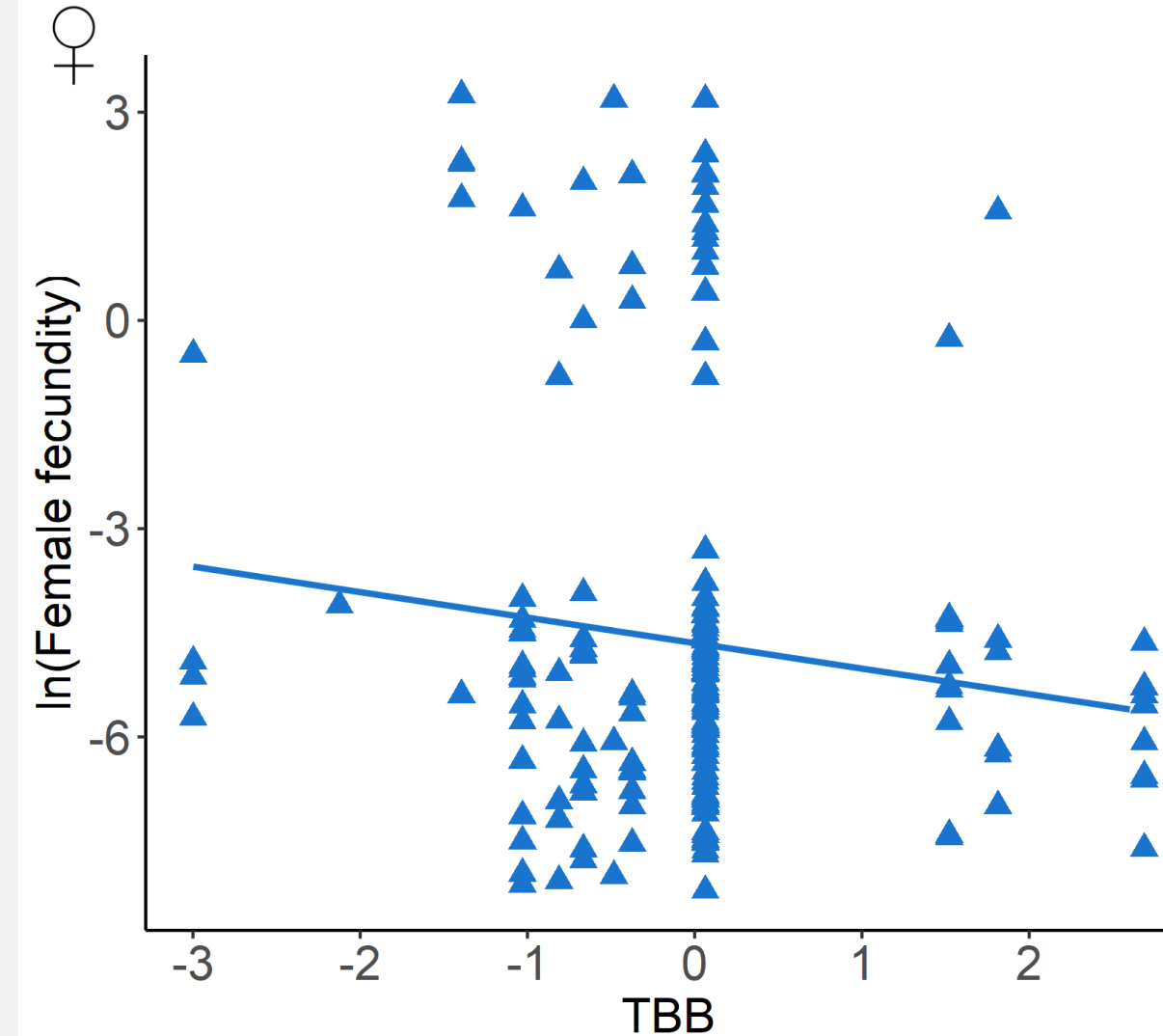
♀ fecundity of the more competed trees increased with increasing TBB



Fecundity selection

High E

♀ and ♂ fecundity decreased with increasing TBB at high elevation

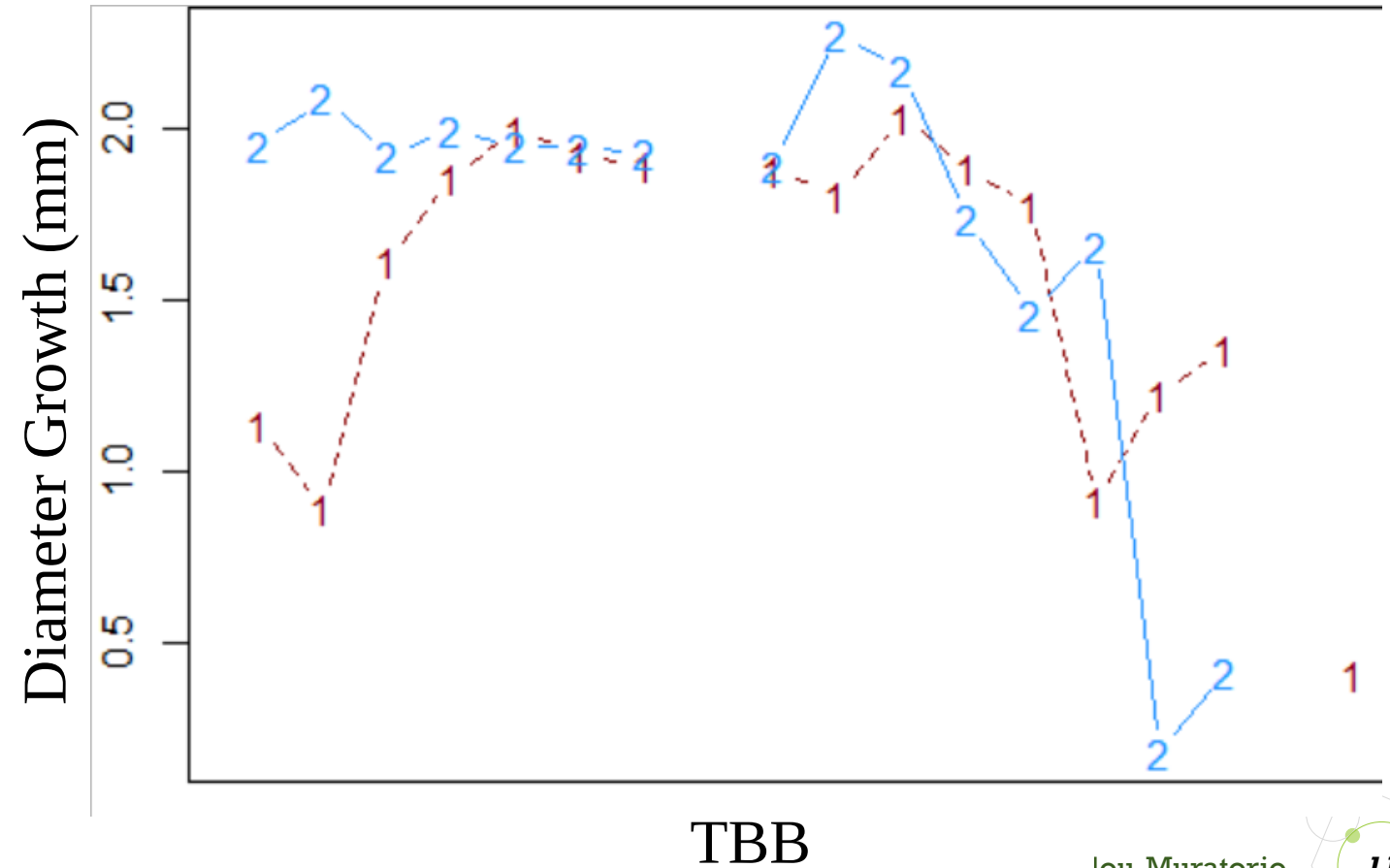


Viability selection

Diameter growth lower for:

- Seedling with late budburst at both plots
- Seedling with early budburst at plot N1

1= Low elevation 2= High elevation



Synthesis: components of selection on beech spring phenology



Stabilizing selection on TBB through ♂ fecundity at both plots

Directional fecundity selection for early budburst through:

- ♀ fecundity at both plots
- ♂ fecundity at high E

Directional fecundity selection for late budburst in small trees through ♀ fecundity at low E.

Directional viability selection for early budburst through growth at high E



Late



TBB



Early

Synthesis: components of selection on beech spring phenology



- One of the first estimation of the strength of **assortative mating** in a tree species, and of **significant Bateman's gradient** for ♂ **fecundity**
- **Selection for earlier budburst** though ♀ fecundity and vegetative performance, consistent with the literature (Geber and Griffen 2003; Munguía-Rosas et al. 2011, Austen et al. 2017)
- Particularly clear **at high elevation**, in line with patterns of genetic differentiation for TBB in beech (Gömöry and Paule 2011; Gauzere et al. 2020)
- **At low elevation**, late budburst was adaptative for small trees: indicative of a **water-saving strategy** (delayed budburst → drought resistance), co-existing with a **water-uptake strategy** (early budburst) (Bontemps et al. 2017)
- Difficulty in estimating selection mediated by late frosts

Thank you for your attention



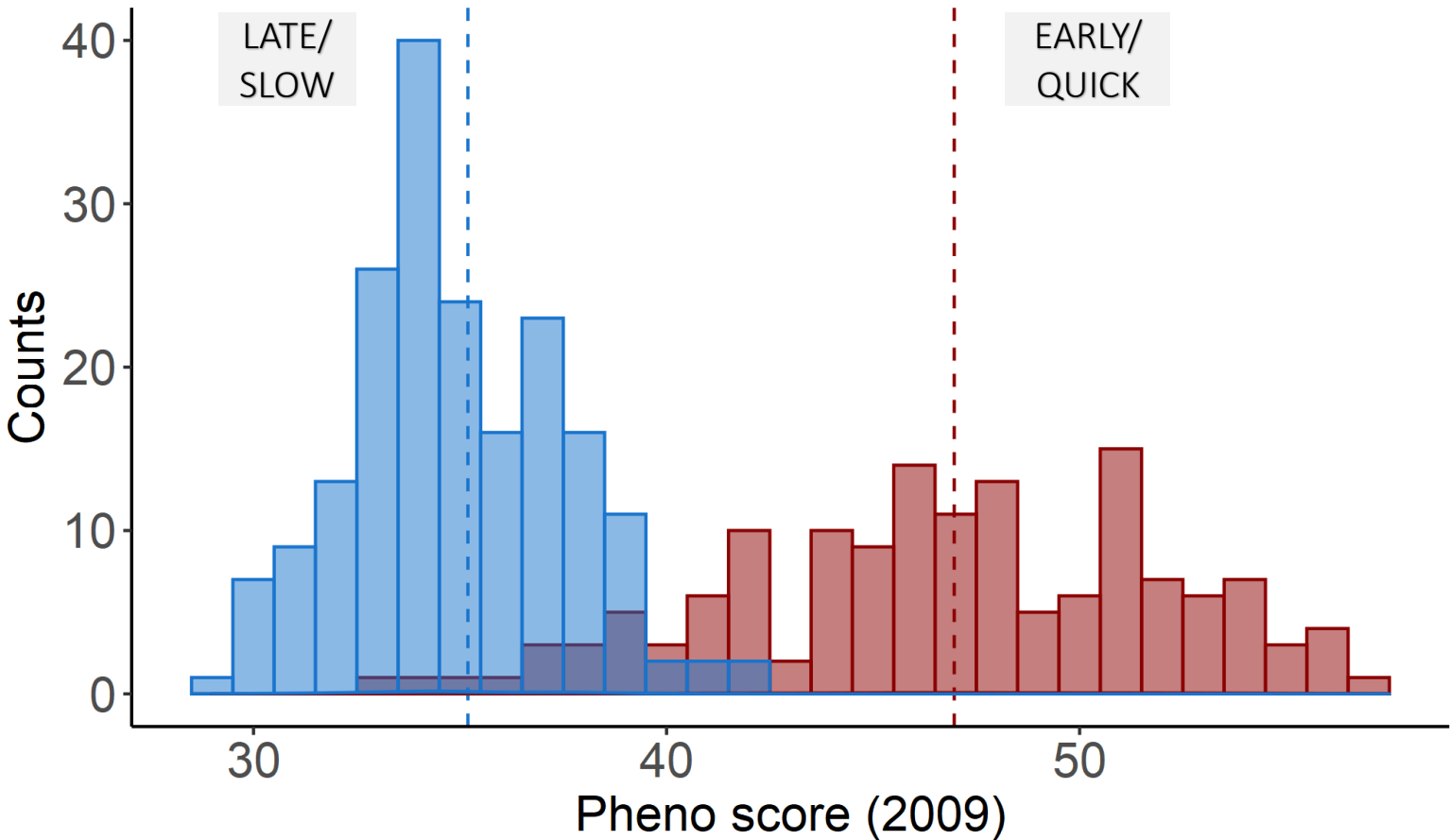
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Distribution of phenological scores

- Low elevation: 15 dates of observations
- High elevation: 13 dates of observations

Plot ■ Low Elev ■ High Elev



Phenological stages

- 1: dormant
- 2: swelling



- 3: Bud scales are broken



- 4: Leaves are emerging



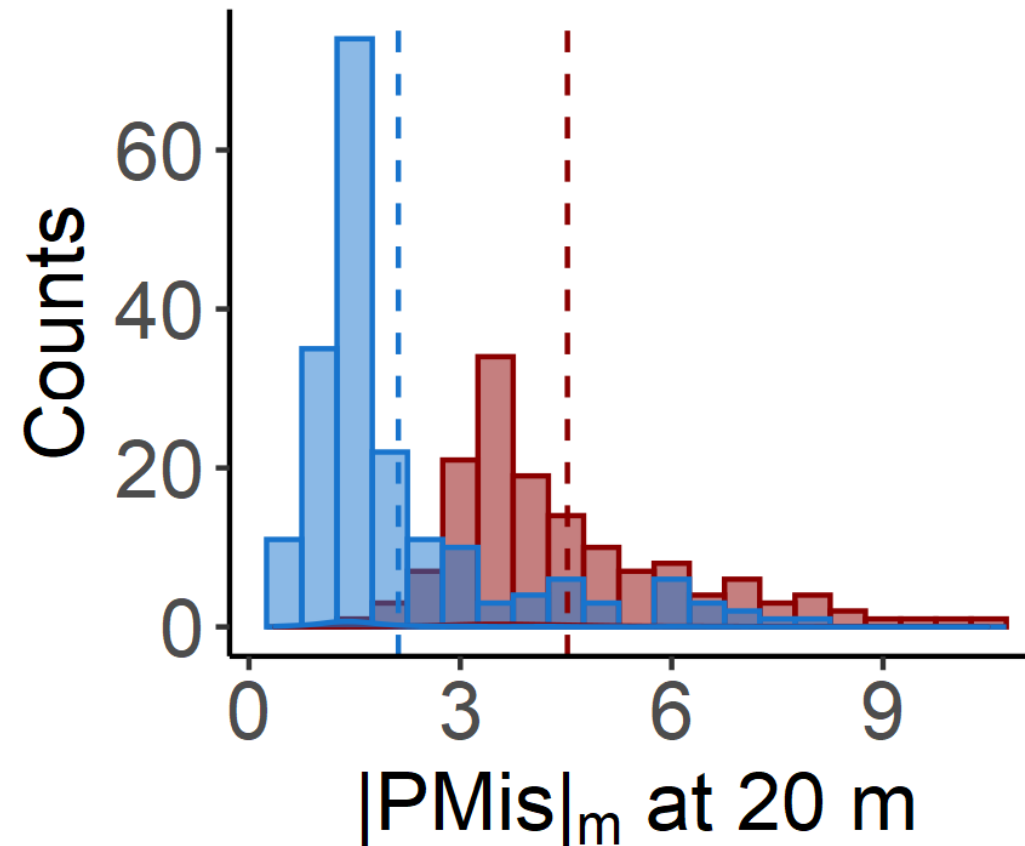
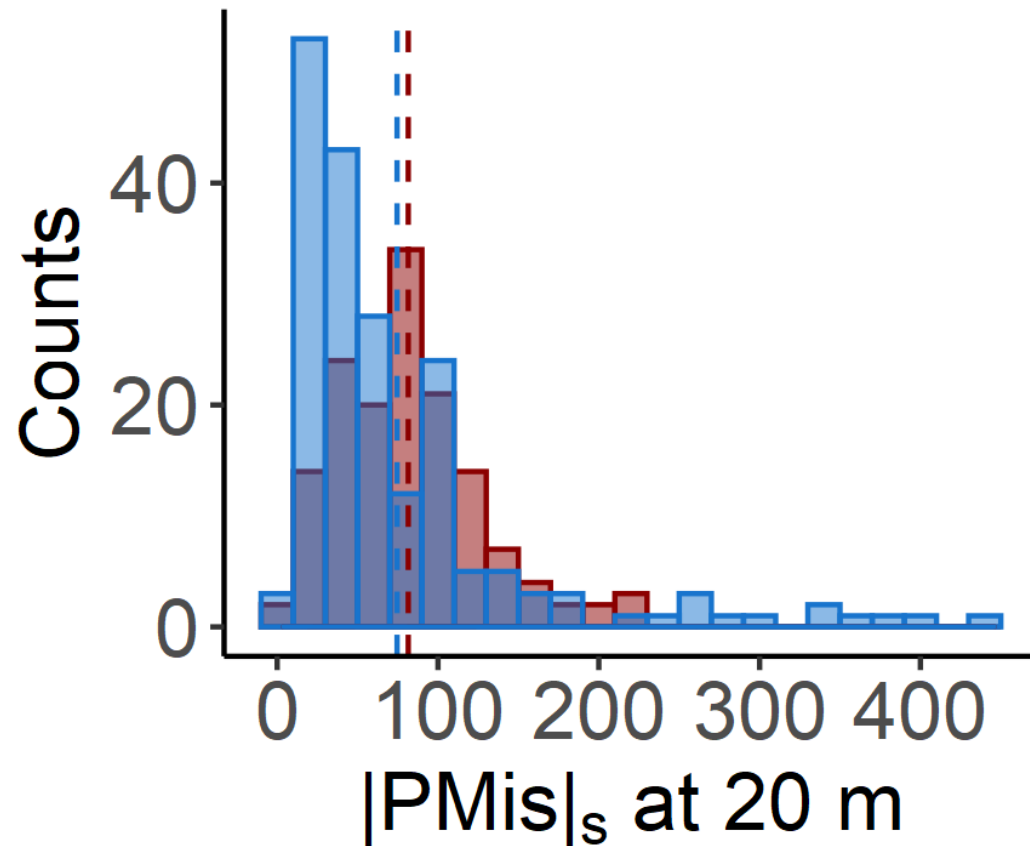
- 5: Leaves are spread out



Distribution of phenological mismatches

$|Pmis|_s$ = sum of difference in TBB between the focal tress and its neighbors

$|Pmis|_m$ = mean of difference in TBB between the focal tress and its neighbors



Distribution of phenological scores

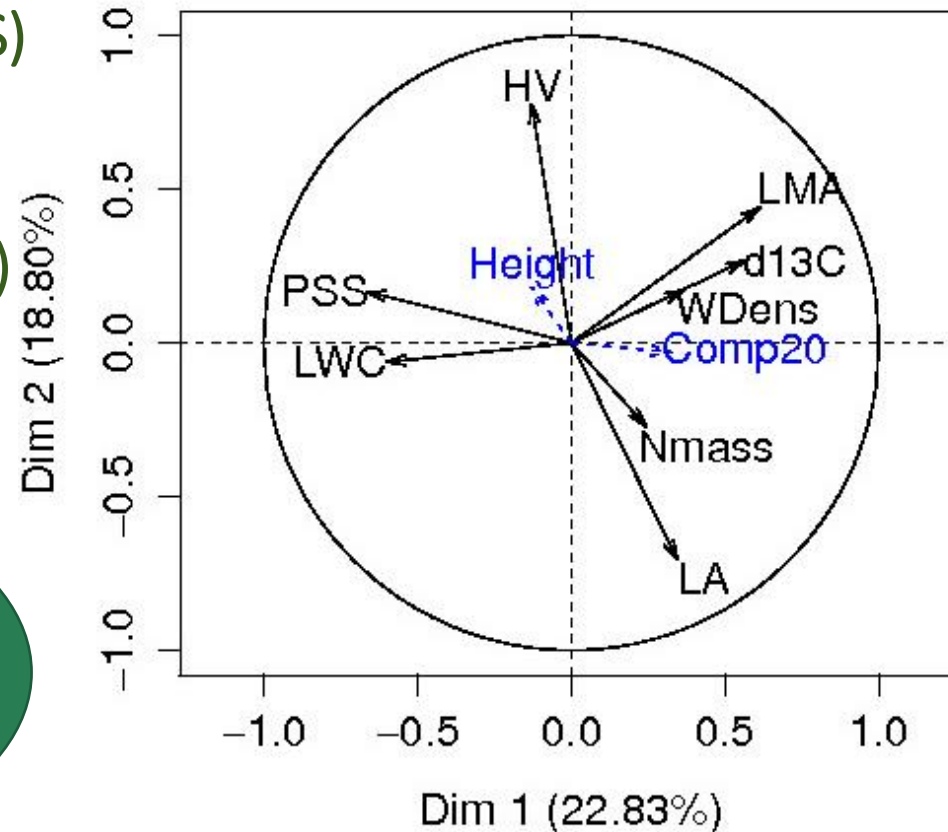
Bontemps et al. 2017. Oikos

Low E

Temperature
Humidity

Early leaf unfolding (high PSS)
Low water use efficiency
(d13C)
Low leaf mass per area (LMA)
High water content (LWC)

**water-uptake
strategy**



Late leaf unfolding (low PSS)
High water use efficiency
(d13C)
High leaf mass per area
(LMA)
Low water content (LWC)

**water-saving
strategy**

Genetic clines as the signature of local adaptation driven by the timing of budburst

- Co-gradient versus counter-gradient
- counter-gradient $\leftrightarrow$ maladaptive plasticity (Connover & Shultz 2003) ?

