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Divergent evolution of genetic sex determination along environmental gradients

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Backgroundinformation

Main question: How do genetic sex determination systems evolve when gene expression is influenced by environmental conditions?

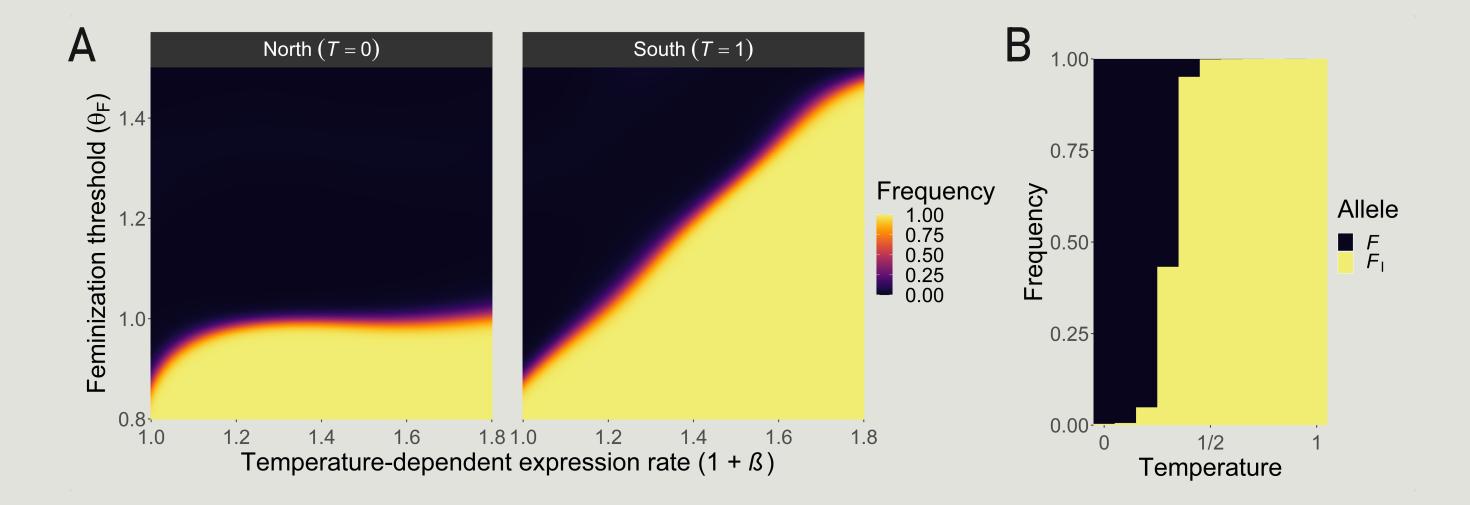
Sex determination



- Feminizing gene
 Masculinizing gene Environment —
- Sex determination is often affected by genetic and environmental factors
- Environmental perturbance may lead to intersexual development with zero fitness
- Unclear how spatial heterogeneity affects evolution of sex determination systems

Evolution of a dominant feminizer $F_{\rm I}$

 F_1 : fully insensitive to M_{v} and M_{Δ} , net expression exceeds θ_{F} , so that carriers are always female



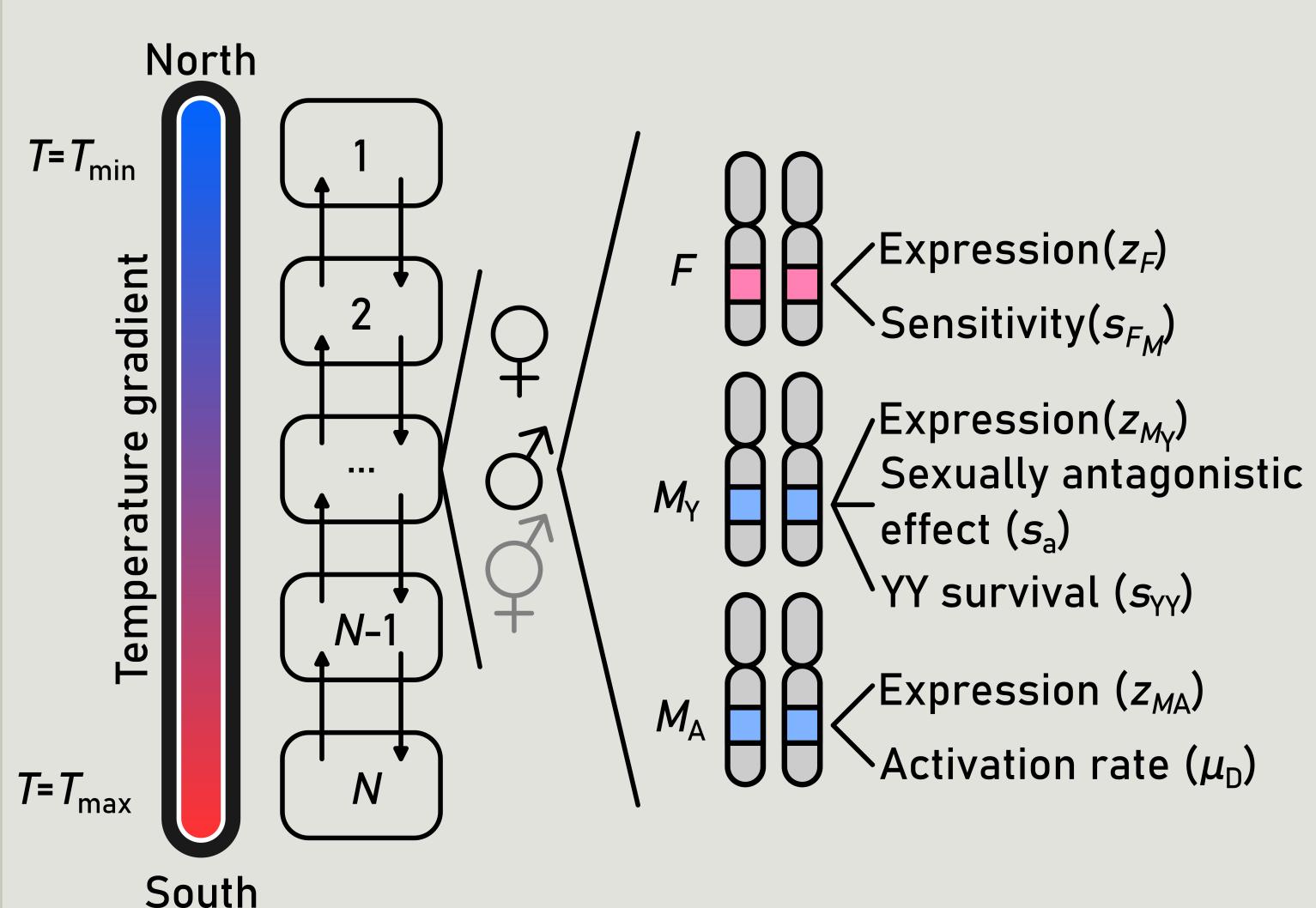
(A) F_{I} evolves when feminization threshold θ_{F} is low (left) or when temperature-dependent overexpression becomes sufficiently strong (right)





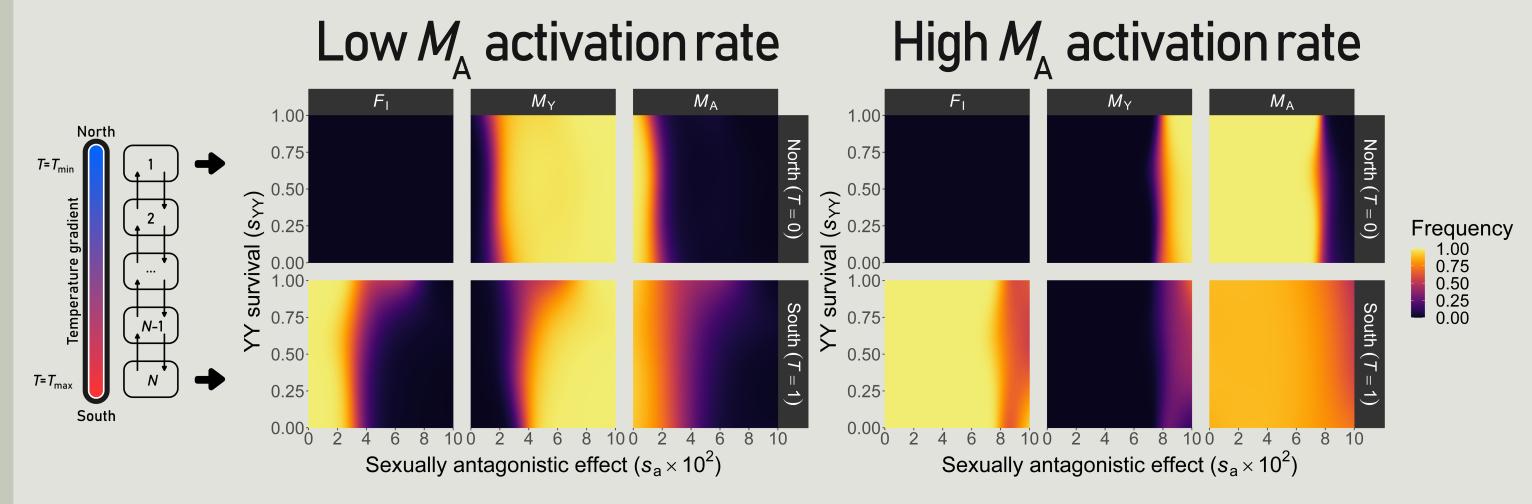
 Possible link between environmental variation and polygenic sex determination

> (B) Temperature-dependent invasion of F_1 may be restricted to warmer demes; environmental variation leads to within - population differentiation



Model overview

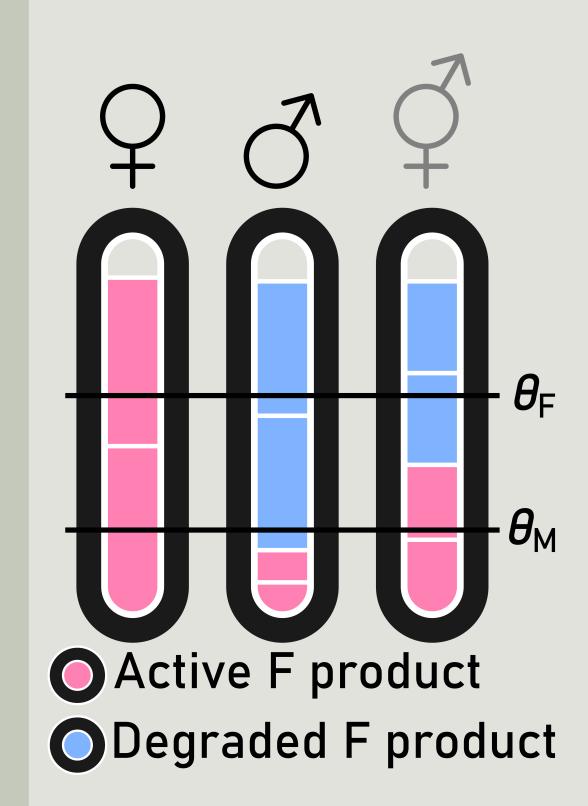
Frequency gradients at multiple loci



• F frequency gradients shaped by temperature; net expression too low at 7=0 for F, to evolve, but sufficient at higher temperatures

- Agent-based simulations
- Demic population with dispersal
- Non-overlapping generations
- Ancestral Y-chromosome M, with fitness effects
- Denovoevolution of M

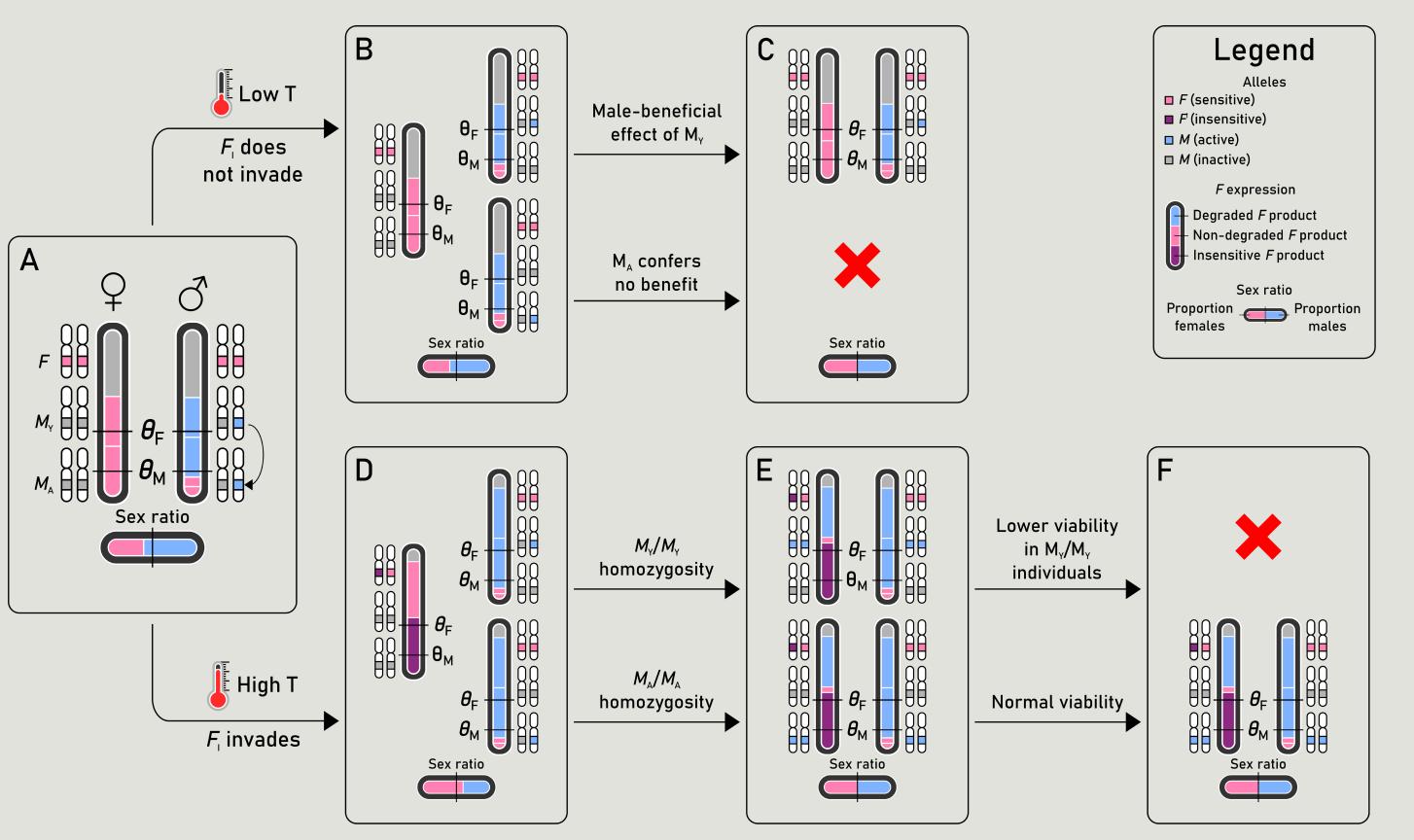
Sex determination gene functions and evolution



- Sex is determined based on net expression of the F gene (\widehat{z}_{F}) relative to the feminization and masculinization thresholds $\theta_{\rm F}$ and $\theta_{\rm M}$
- M_{γ} and M_{Δ} function as masculinizing genes by breaking down the feminizing F product
- Mutations can occur in *F* expression and

• M_{v} versus M_{Δ} polymorphism: sexual antagonistic selection maintains M_{v} over M_{Δ} in absence of F_{Γ} ; costs in females and reduced viability in YY homozygotes drive M_{v} loss, followed by fixation of M_{h} in presence of F_{I}

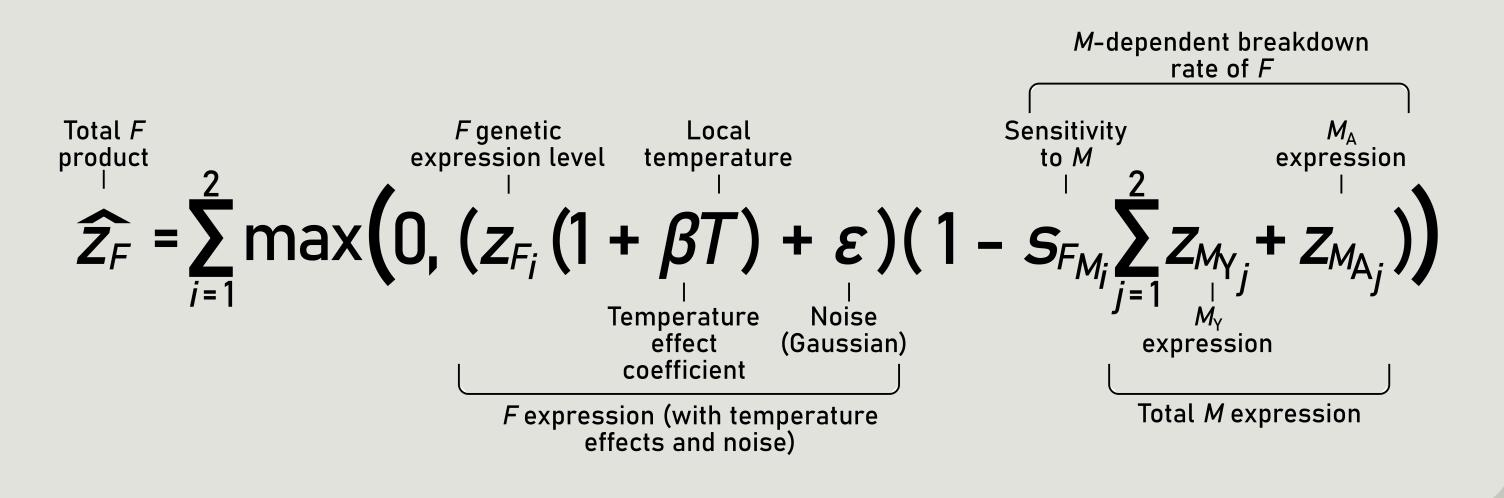




sensitivity as well as M_{γ} and M_{Λ} expression

 Small proportion of mutations are null mutations that set trait value to 0

• M_{Λ} becomes expressed *de novo* at a rate μ_{Π}



Environment modulates scope for evolutionary change, promoting divergent evolution leading to polygenic sex determination

