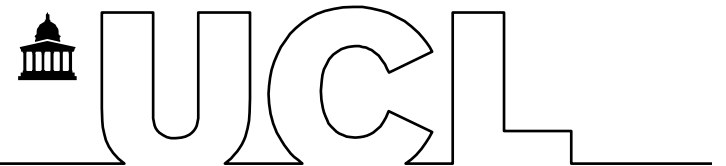
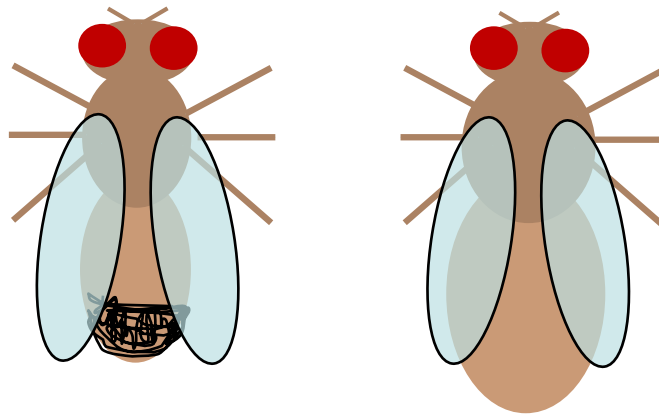


Genome-wide sexually antagonistic variants reveal longstanding constraints on sexual dimorphism in the fruit fly

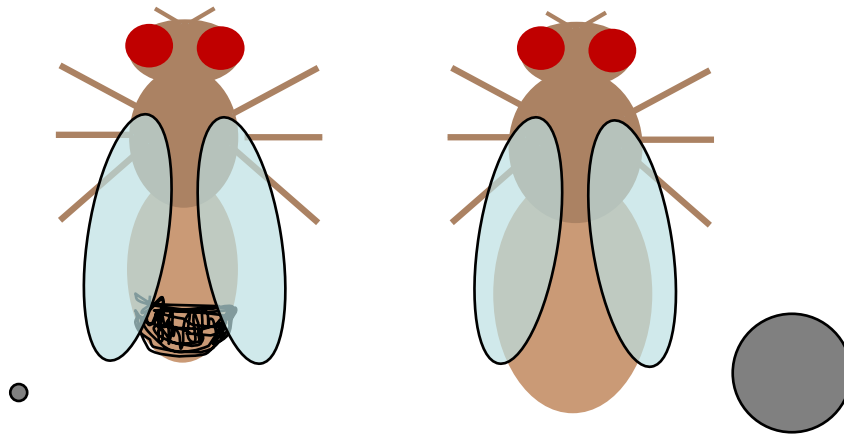
Max Reuter



Sexual dimorphism



Sexual dimorphism



Dimorphism and genes

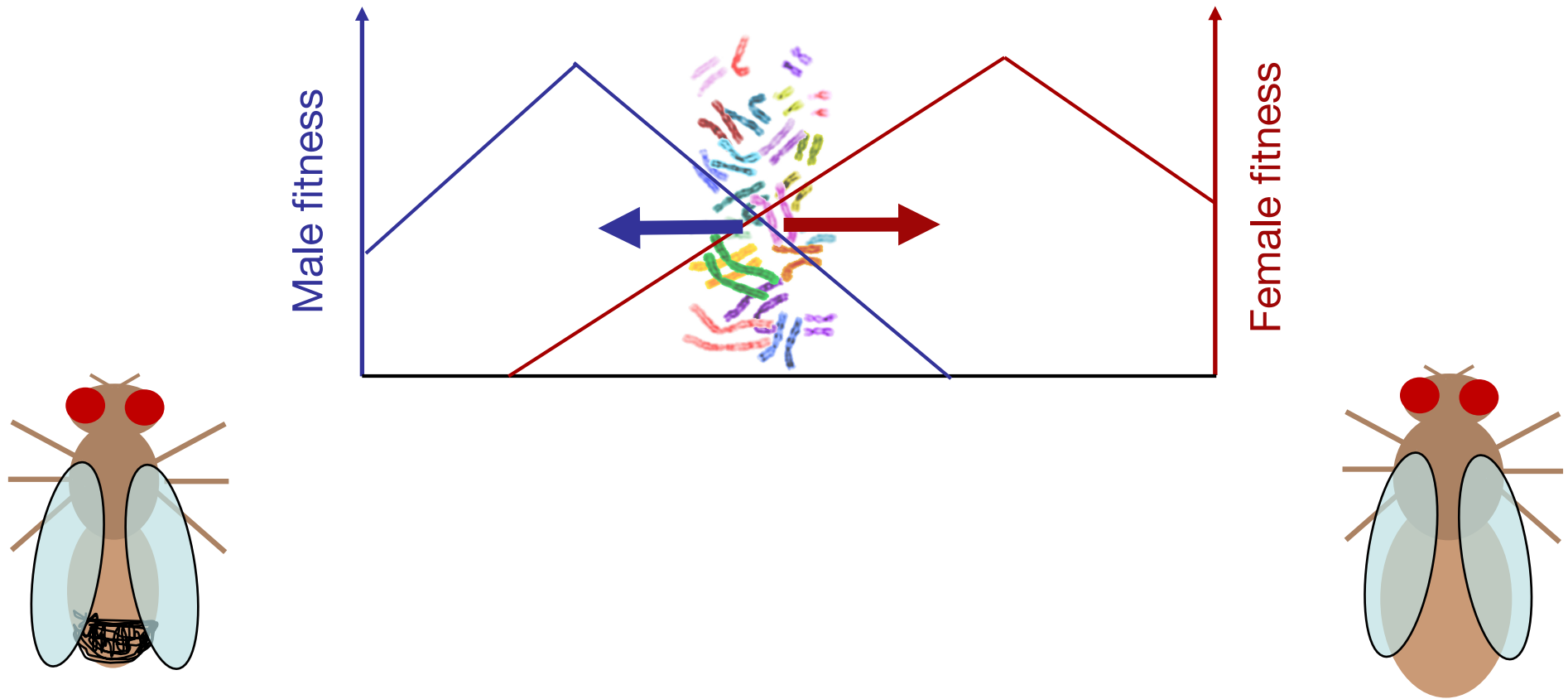
Males and females share genomes

Few genes are restricted to one sex

Organism	Total genes	Y/W genes
Human	20,441	71
Jungle fowl	18,346	25
Fruitfly	13,918	22

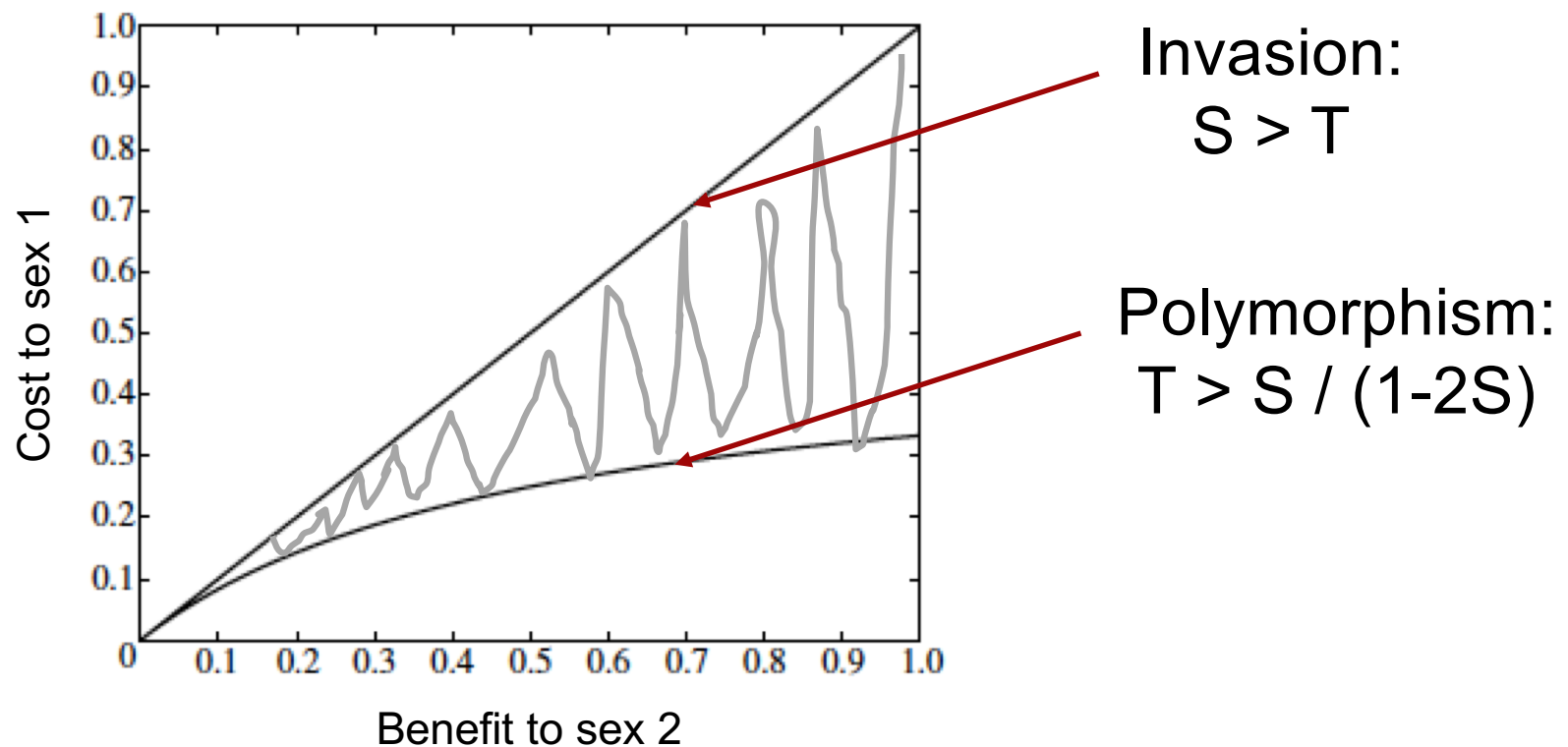


Sexual antagonism



Sexual antagonism in theory

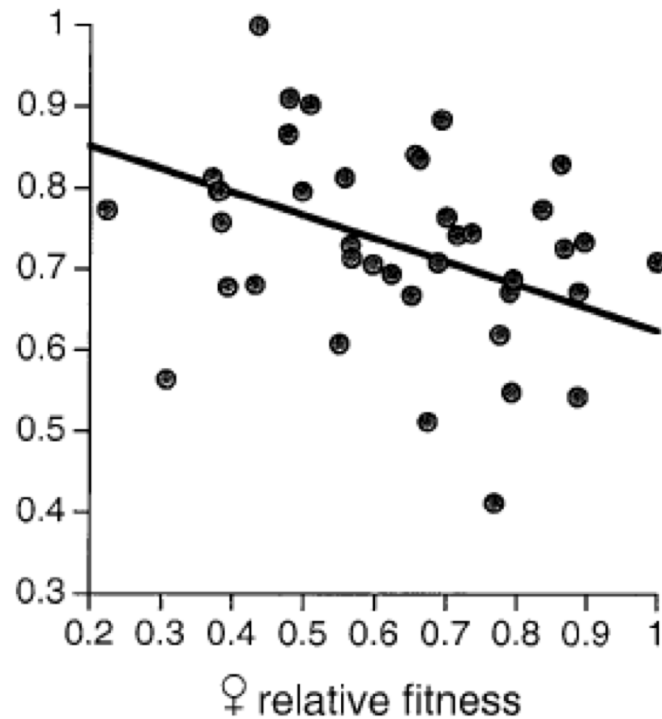
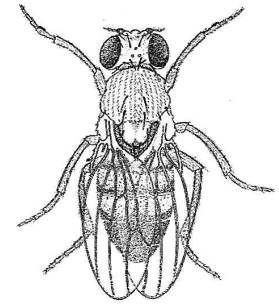
Population genetic models



Rice (1984); Gavrilets & Rice (2006)

Antagonism in real organisms

Drosophila melanogaster – LH_M



Chippindale et al. (2001)

Antagonism in general

Widespread

Many species of animals and plants

Sexual dimorphism often is incomplete

Why does antagonism persist?

What are its evolutionary dynamics?

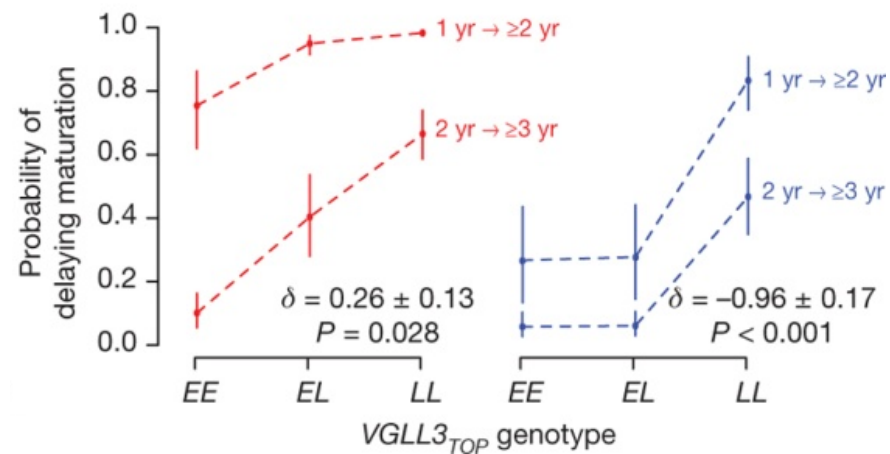
Which loci underlie antagonism?



Genetic basis of antagonism

Largely unknown, individual examples

e.g., maturation/body size QTL in salmon



Barson et al. (2015, Nature)

Genetic basis of antagonism

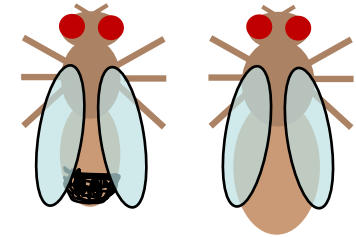
Here: a genome-wide effort in *D. melanogaster* (LH_M)

Which SNPs are sexually antagonistic?

What do they do?

How do they evolve?

Data



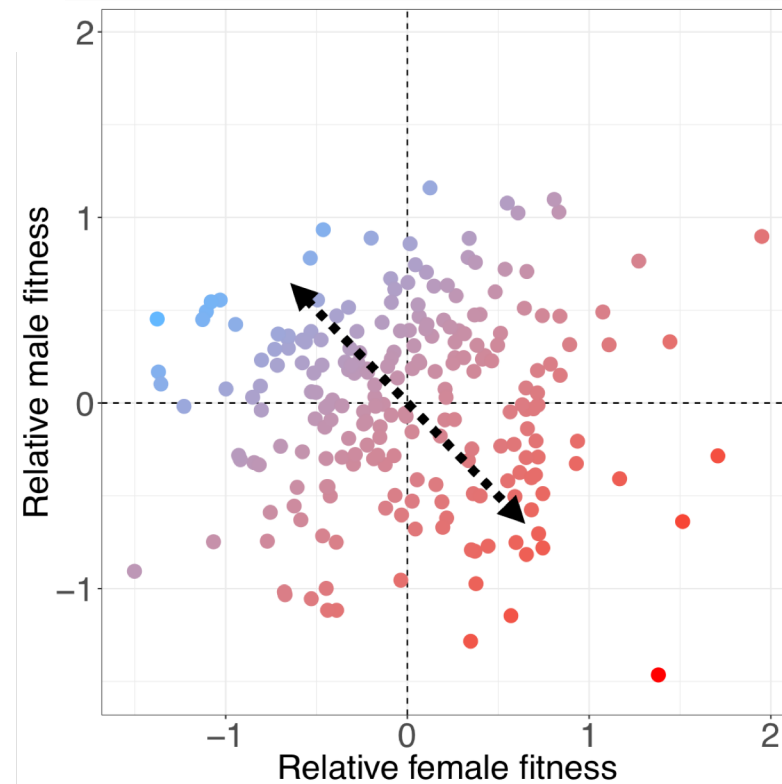
Drosophila melanogaster, LH_M

200+ hemiclinal lines

Measures of male and female competitive fitness

Whole genome sequences, 765,000 SNPs

Quantitative genetics



$$h_f^2 = 0.42, \text{ CI} = (0.30, 0.54)$$

$$h_m^2 = 0.16, \text{ CI} = (0.04, 0.27)$$

$$r_{MF} = 0.15, \text{ CI} = (-0.21, 0.46)$$

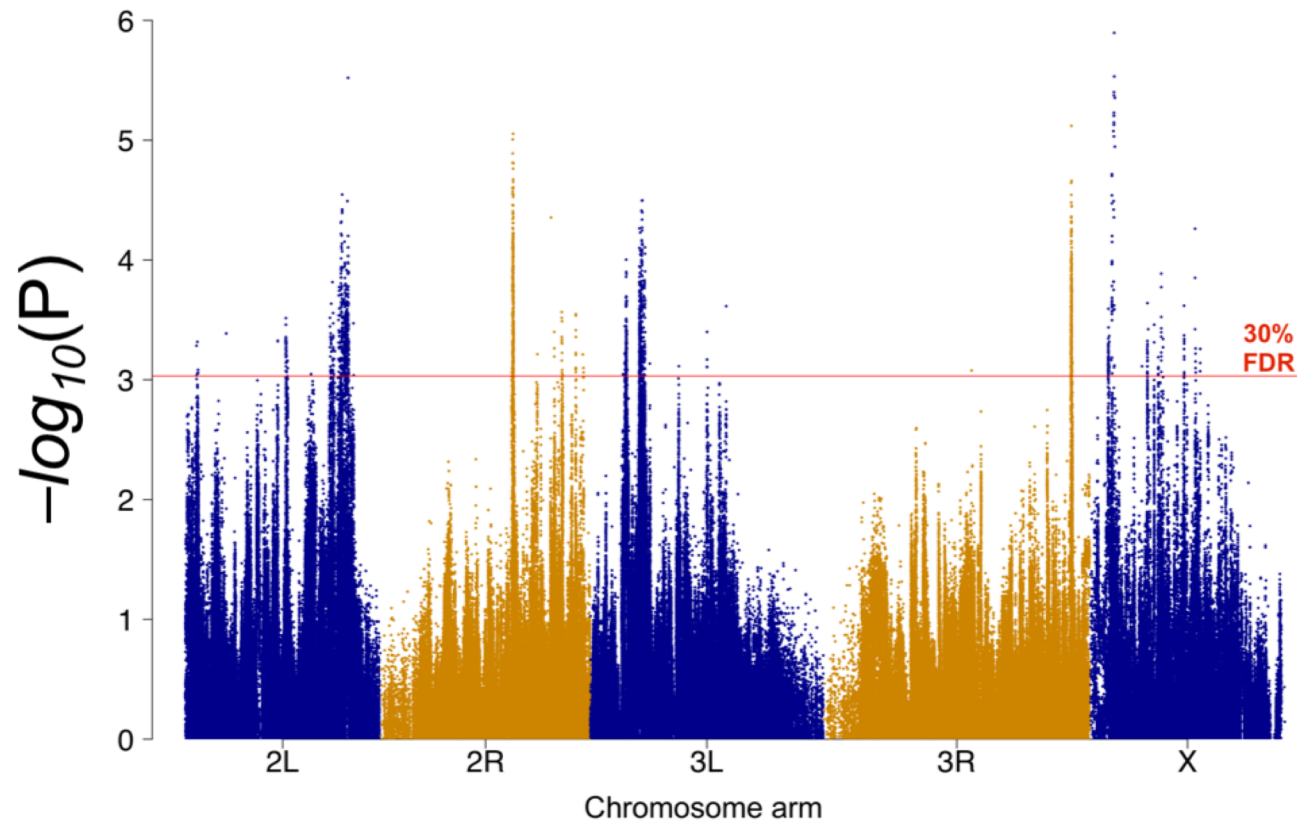
Which SNPs are sexually antagonistic?

What do they do?

How do they evolve?

Candidate SNPs

Univariate GWAS on antagonistic score



2,372 SNPs with $\text{FDR} > 0.3$, 226 clusters

Which SNPs are sexually antagonistic?

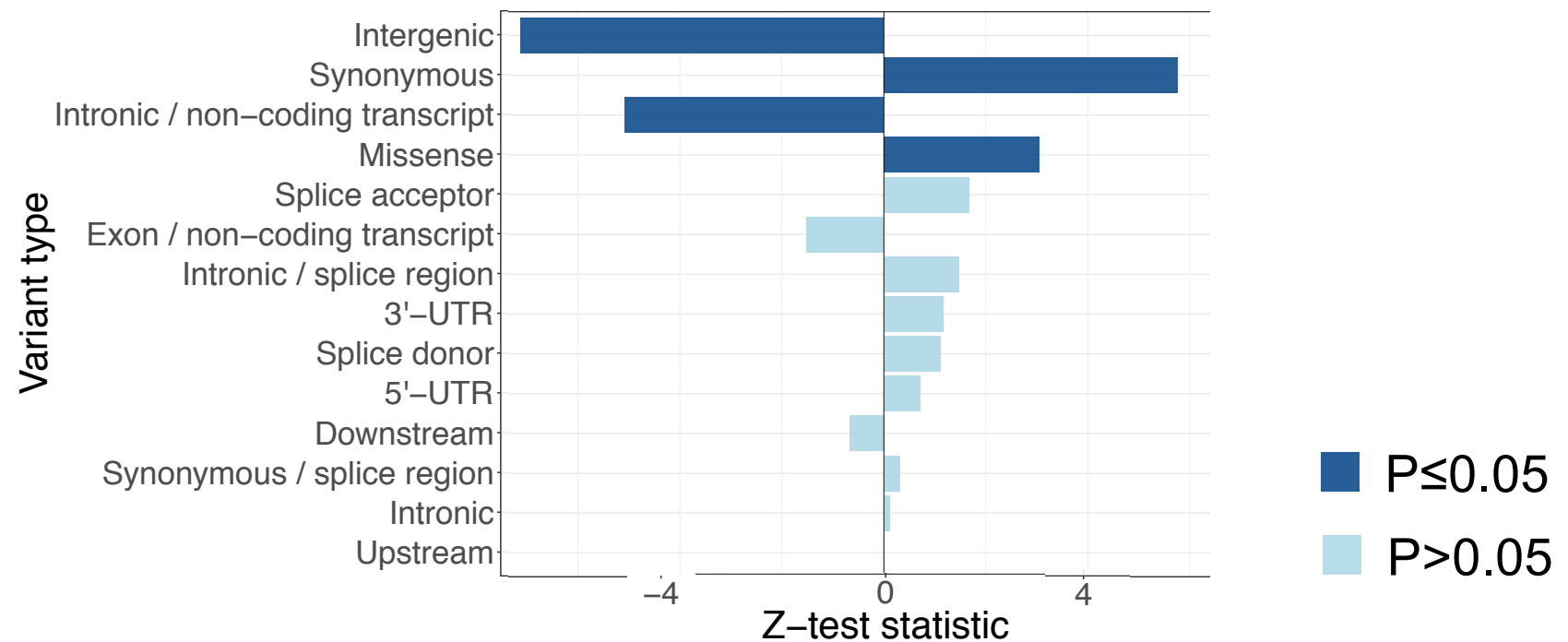
What do they do?

How do they evolve?

Function

Antagonistic SNPs are enriched in coding sequences

Large excess of missense variants

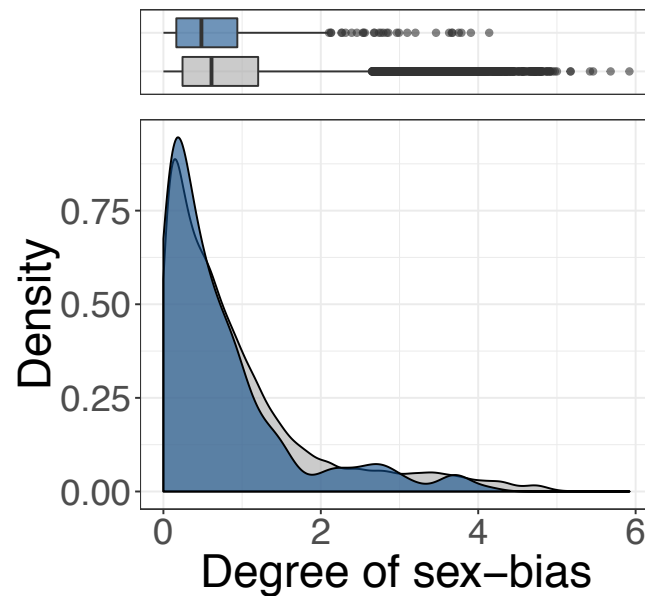


Function

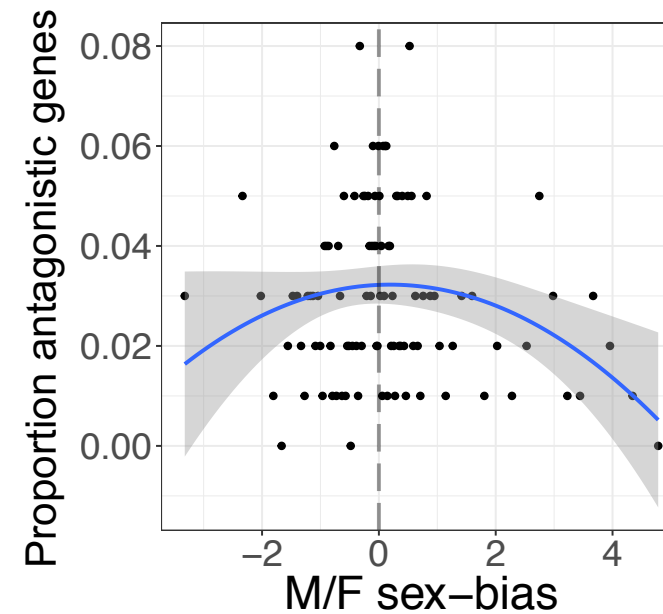
514 genes with ≥ 1 significant SNP

No clear GO enrichments

(Slightly) below-average sex bias in expression



$P < 0.001$



bias²: $P = 0.013$

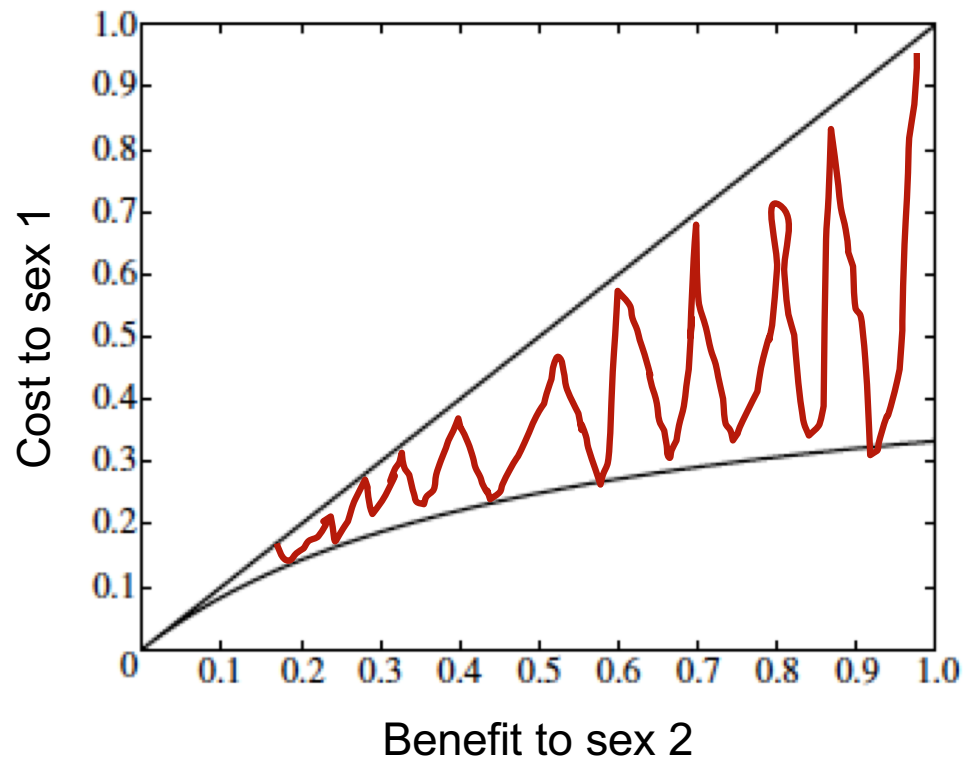
Which loci are sexually antagonistic?

What do they do?

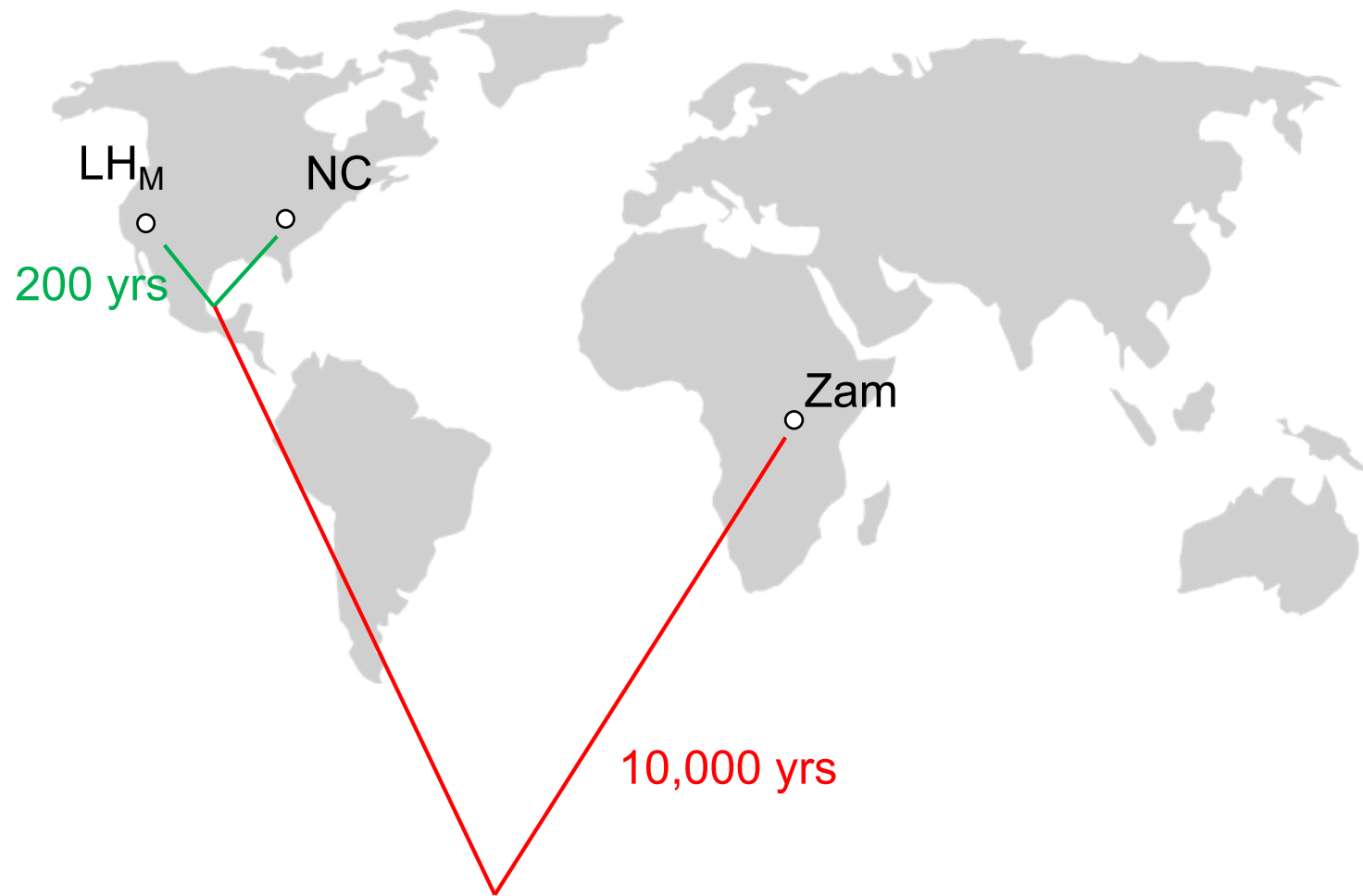
How do they evolve?

Evolutionary dynamics

Antagonism can generate balancing selection

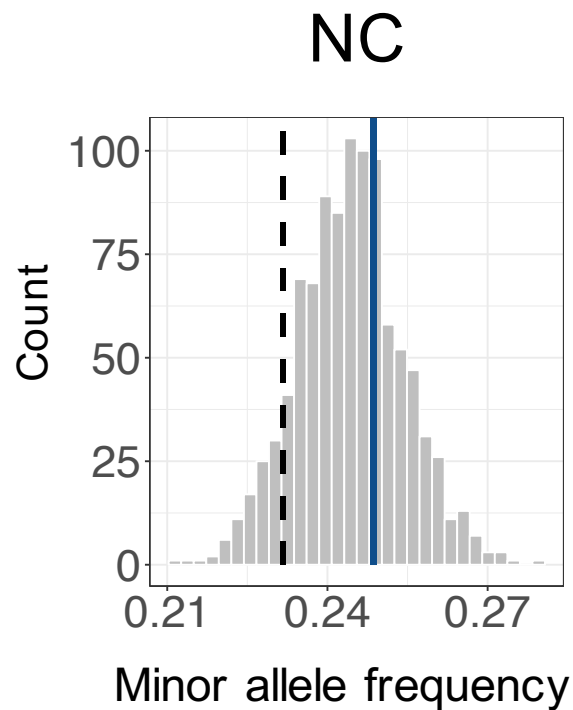


Evolutionary dynamics

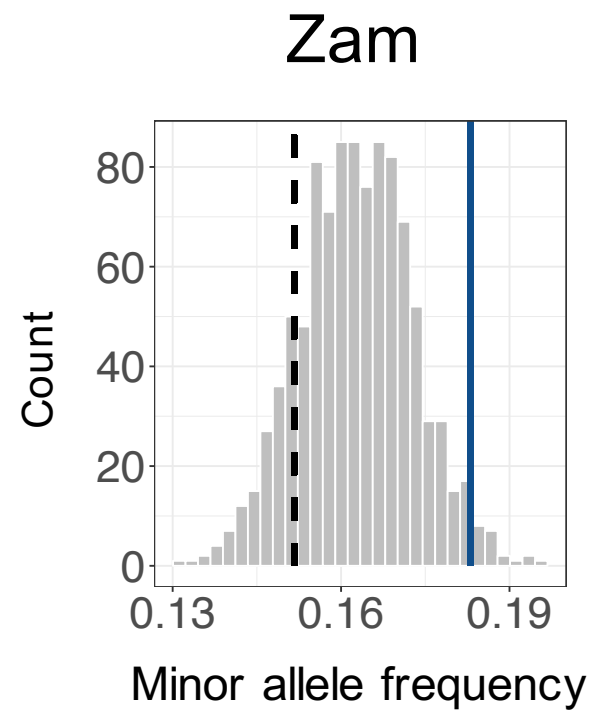


Evolutionary dynamics

Antagonism is associated with elevated MAF



P=0.32



P=0.024

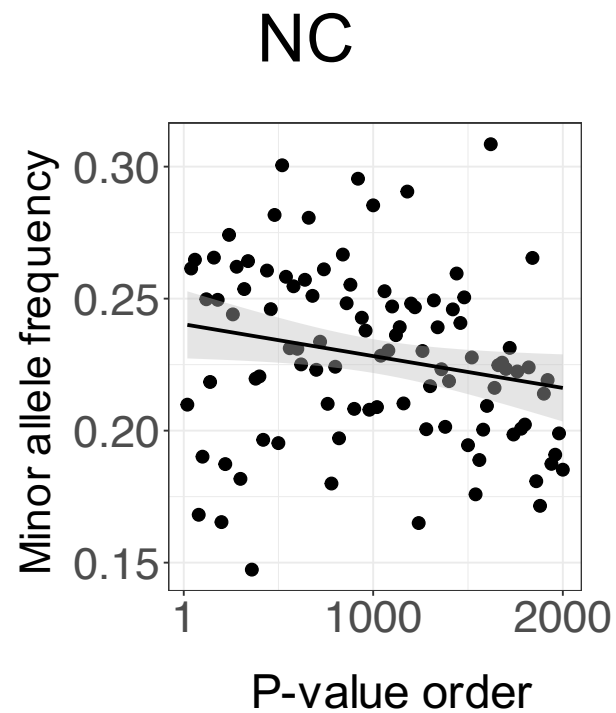
Ant. SNPs

Non-ant. SNPs

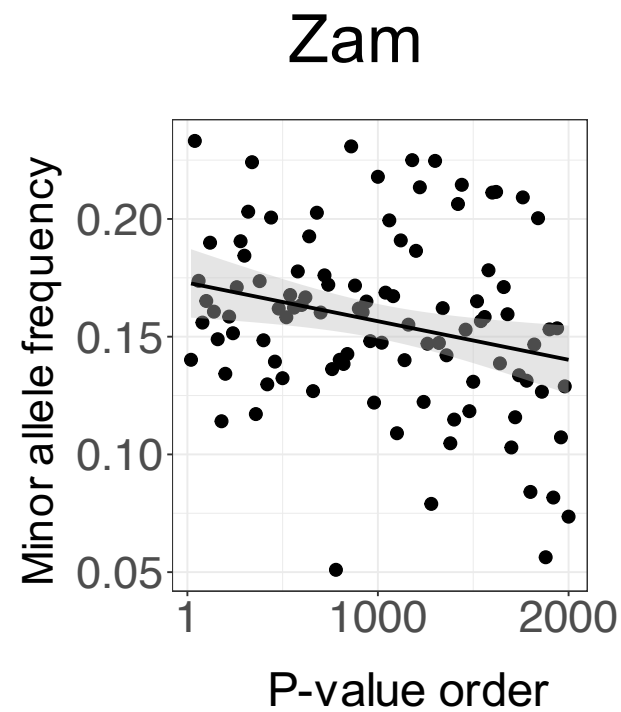
Sets of LH_M freq.-matched SNPs

Evolutionary dynamics

Antagonism is associated with elevated MAF



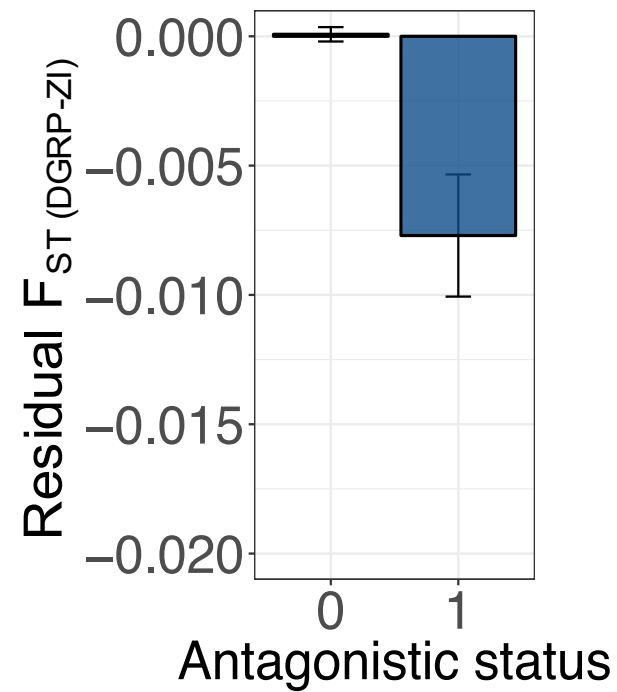
$P=0.044$



$P=0.002$

Evolutionary dynamics

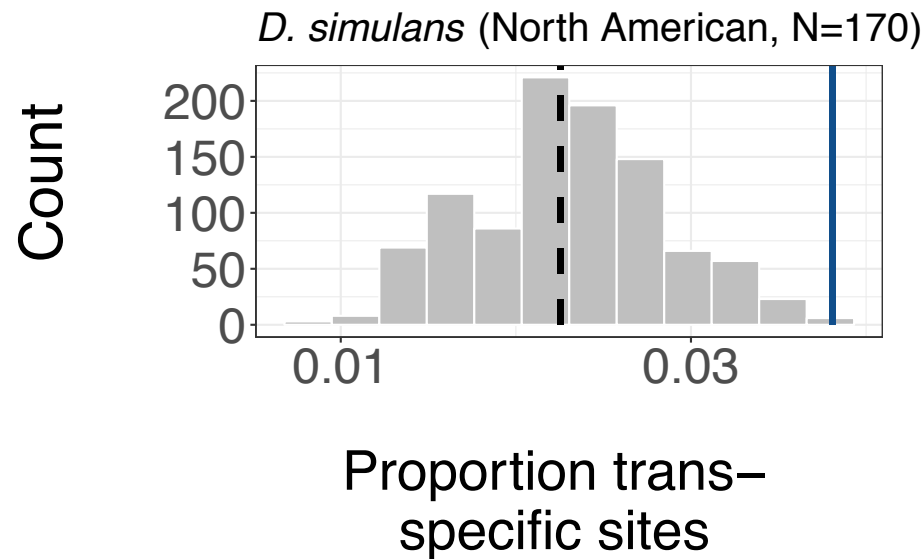
... and reduced population differentiation



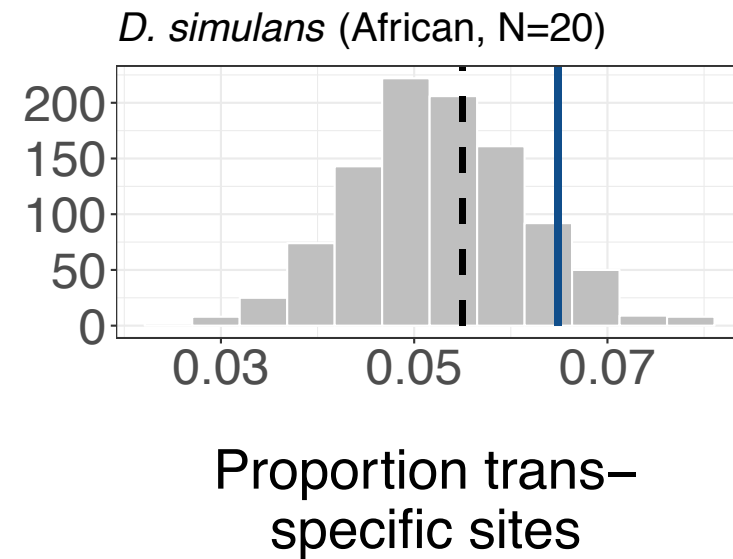
$P < 0.001$

Evolutionary dynamics

... and trans-specific polymorphism with *D. simulans*



$P < 0.001$

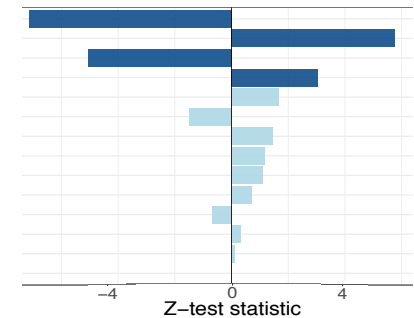


$P = 0.092$

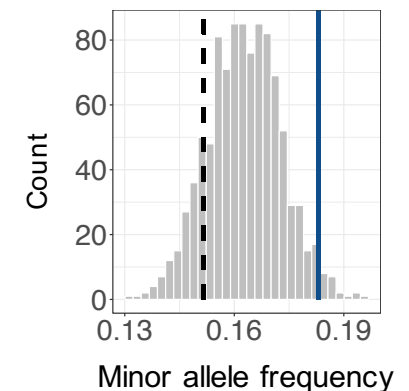
Summary

Genome-wide candidates for sexual antagonism

Adaptive conflict over protein sequence
More difficult/slow to resolve



Antagonism stabilises polymorphism
For long periods of time
Within and across species



Acknowledgements

Filip Ruzicka
Mark Hill
Kevin Fowler
Richard Mott

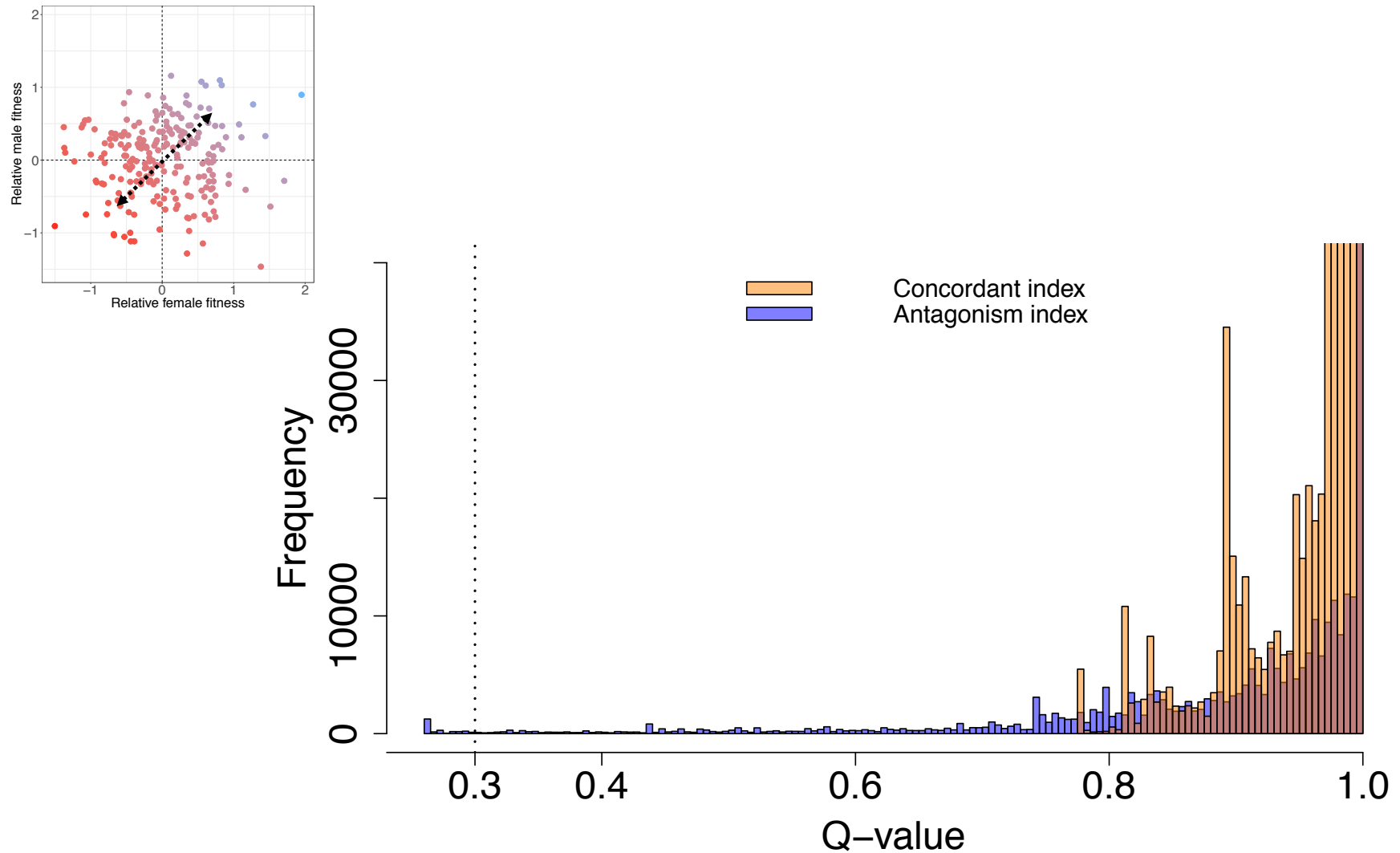
Doug Speed
Aida Andrés

Ted Morrow
Tanya Pennell
Fiona Ingleby
Ilona Flis
Will Gilks



Concordant fitness variation

Highly polygenic, mutation–selection balance



Evolutionary dynamics

Window-wide increase in polymorphism

