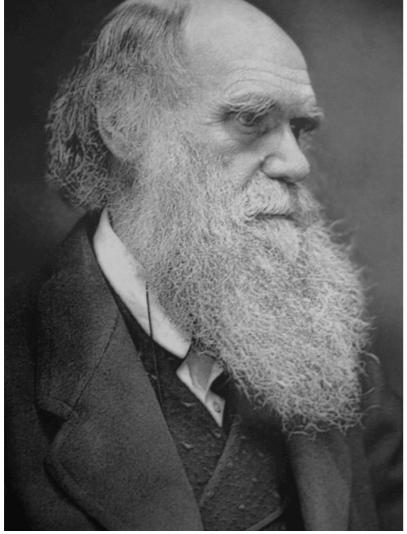


Concepts, islands & continuums: a perspective on speciation genomics



Mark Ravinet
Centre for Ecological and Evolutionary Synthesis
University of Oslo, Norway
@mark_ravinet.mark.ravinet@ibv.uio.no

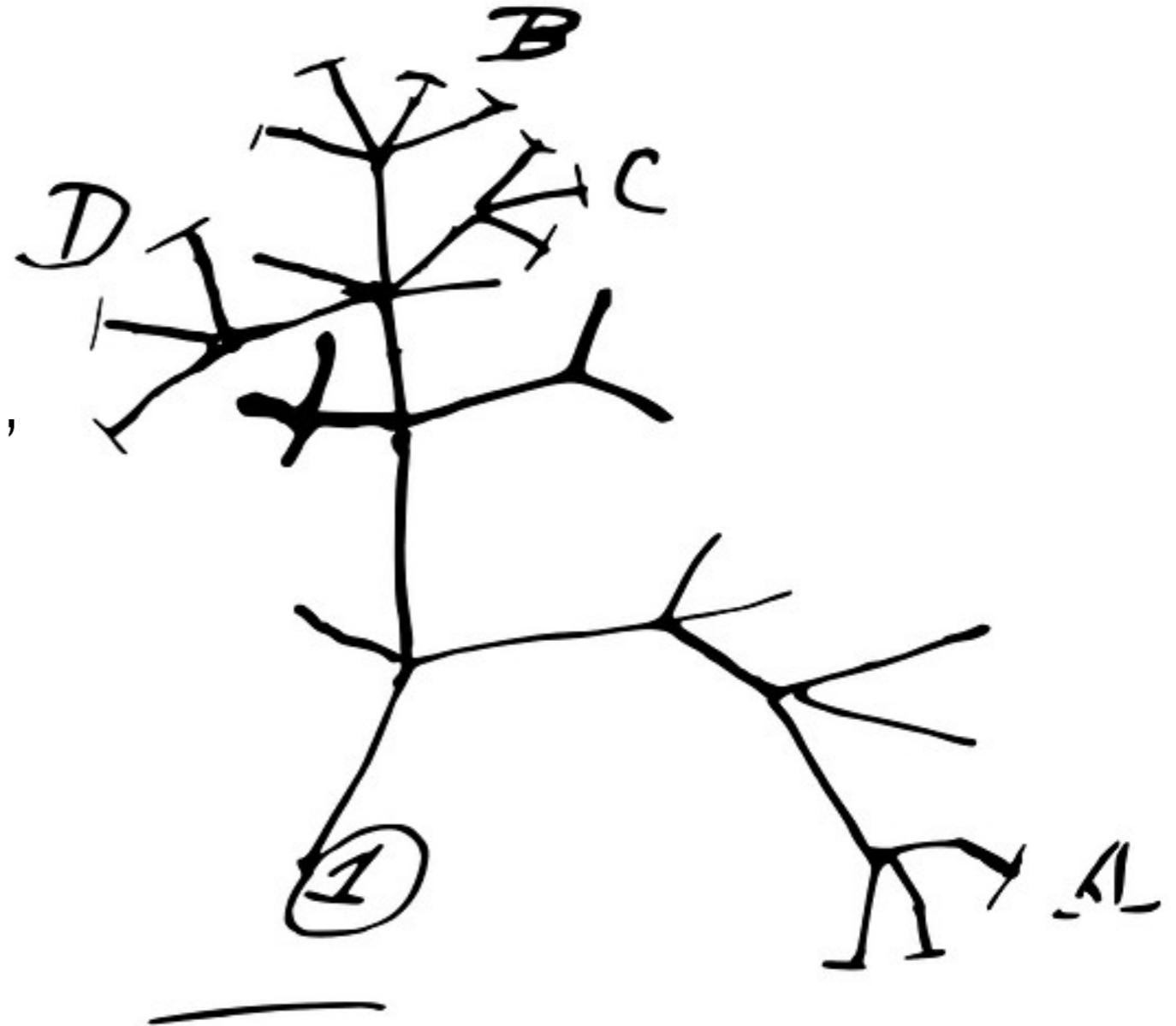
Darwin and the origin



“...that mystery of mysteries...”

Charles Darwin (1859) *The Origin of Species*

I think



Species concepts and the modern synthesis

“Species are groups of interbreeding natural populations... reproductively isolated from other such groups”

Ernst Mayr (1942) *Systematics and the Origin of Species*



“[The] existence of discrete groups... constitutes evidence that some mechanisms... [isolate] them”

Theodosius Dobzhansky (1937) *Genetics and the Origin of Species*

Hybrid zones and gene flow

“Narrow regions in which genetically distinct organisms meet, mate and produce hybrids”

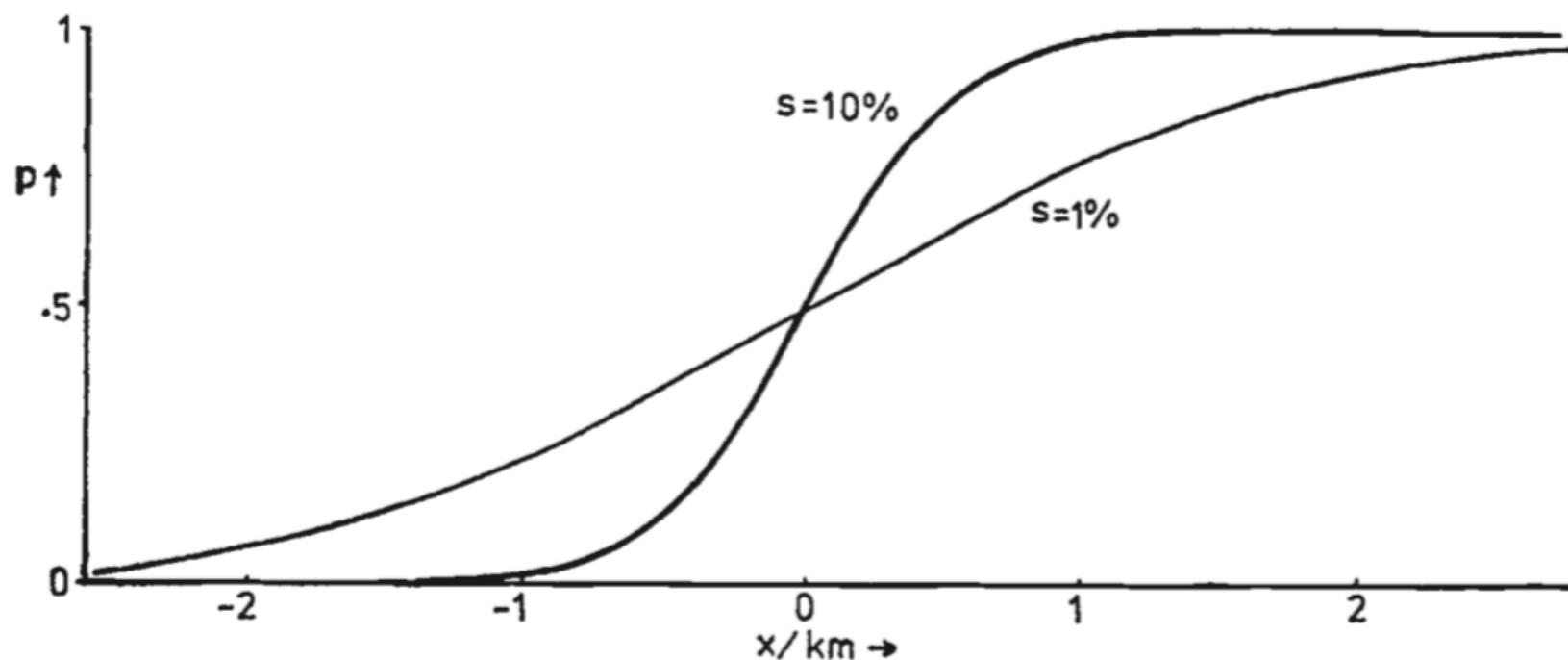


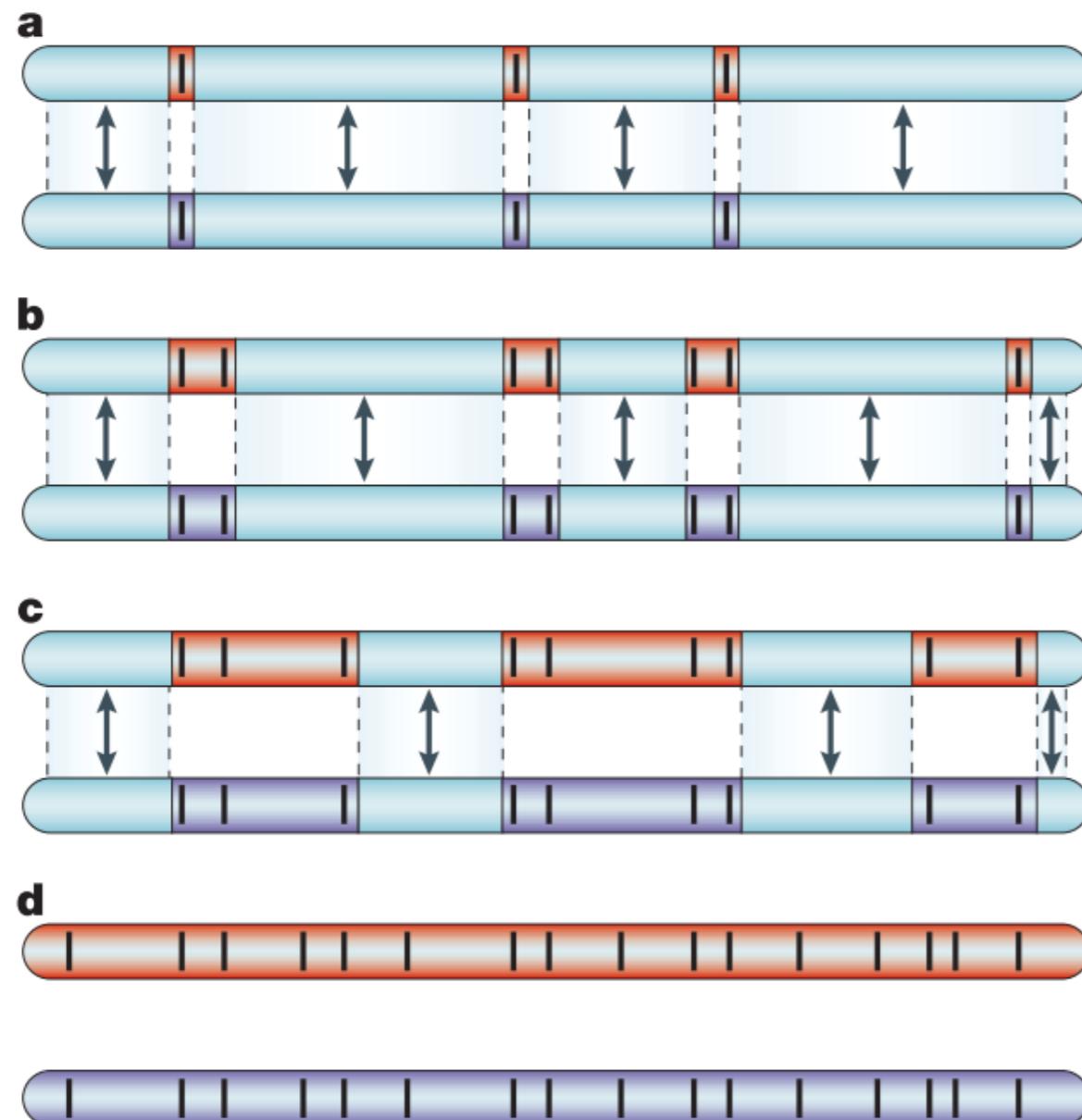
FIG. 1.—Hybrid zones produced by selection against heterozygotes;
dispersal $\sqrt{m} = 112 \text{ m.gen.}^{-\frac{1}{2}}$

Barton (1979) **Heredity**

“Maintained by a balance between dispersal and selection against hybrids”

Barton & Hewitt (1989) **Nature**

The genic concept of speciation



Divergent loci resist gene flow

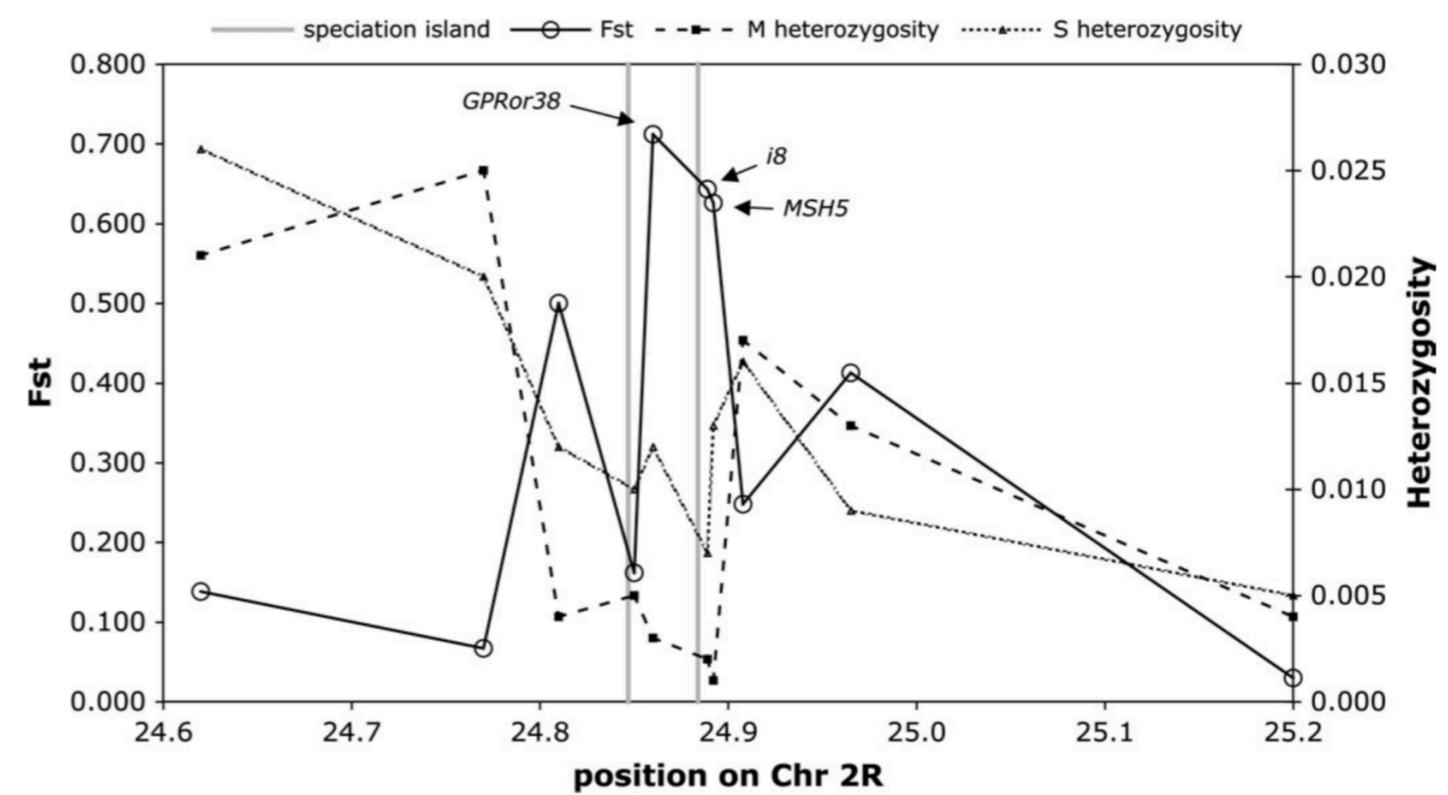
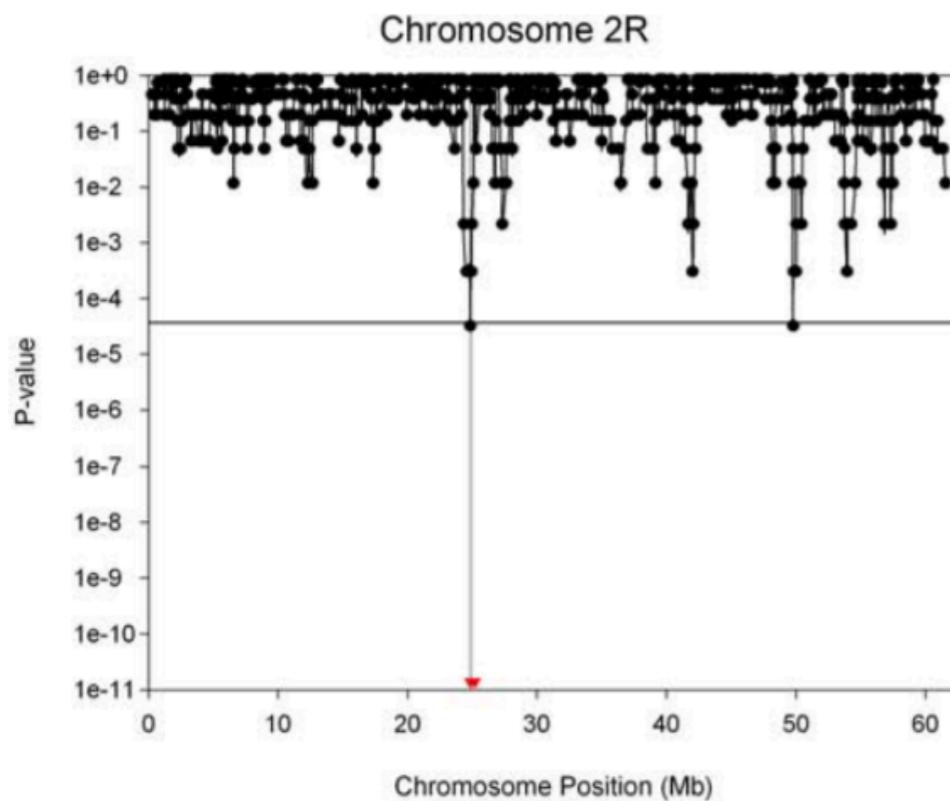
Gene flow continues but linkage builds and divergent regions grow

Complete reproductive isolation evolves

The rise of speciation islands

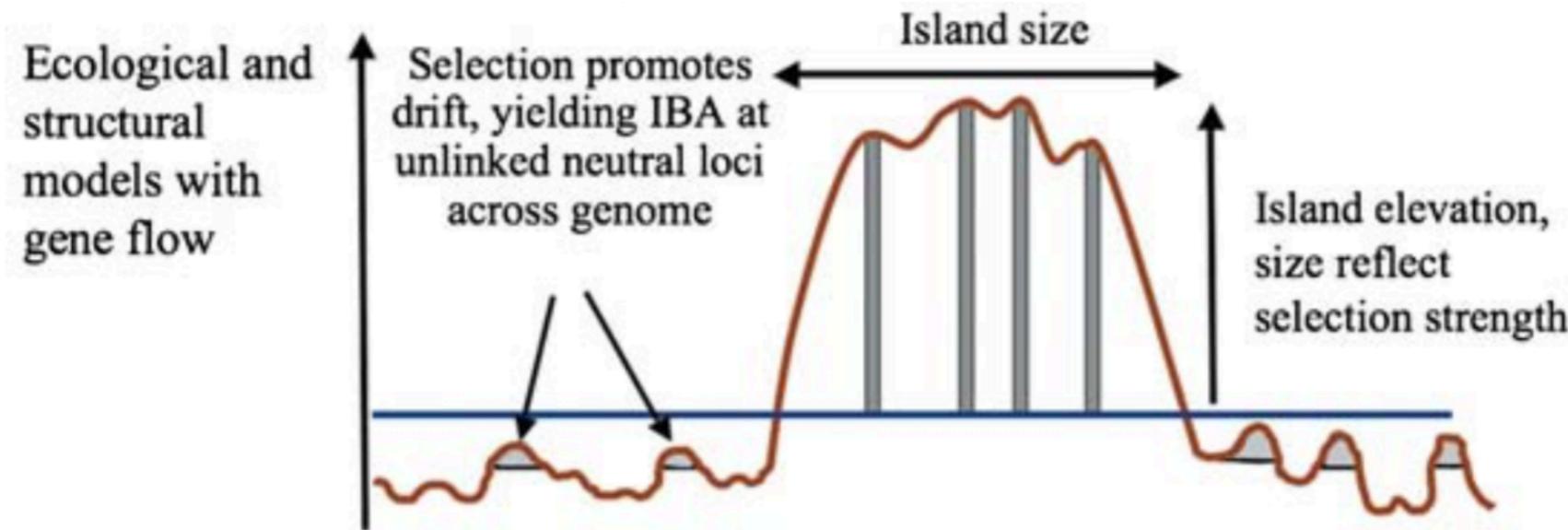


Anopheles gambiae
M + S forms

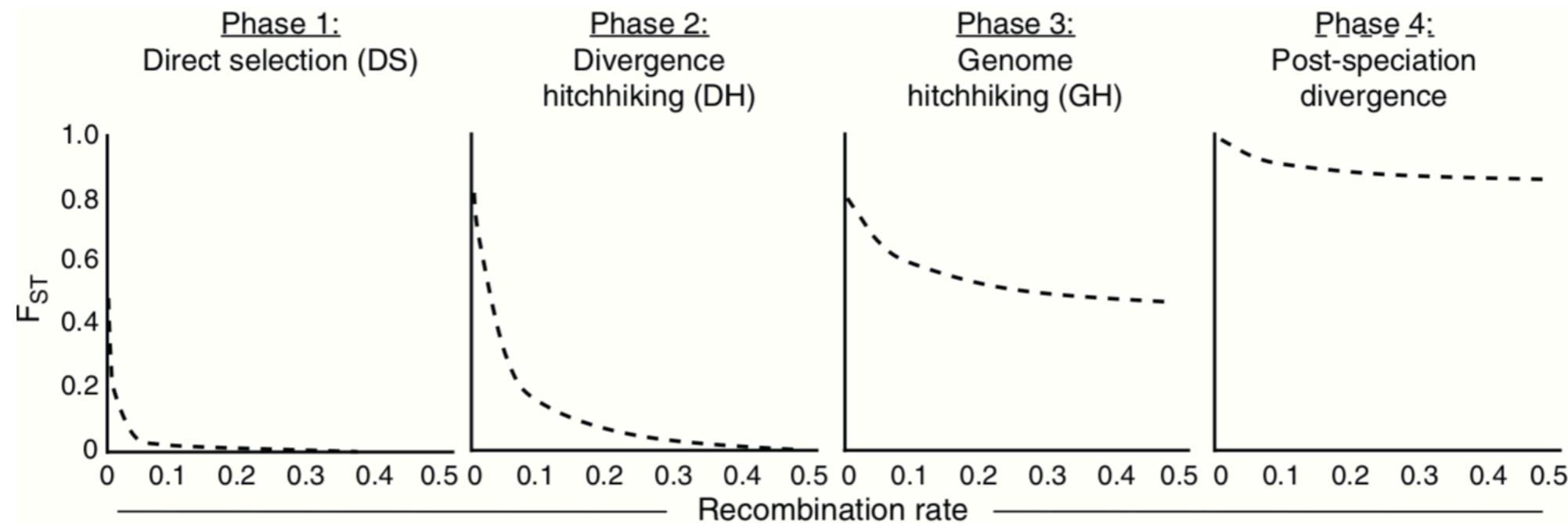


Turner et al (2005) **PLoS Biology**; Turner & Hahn (2007) **MBE**

Speciation islands and processes



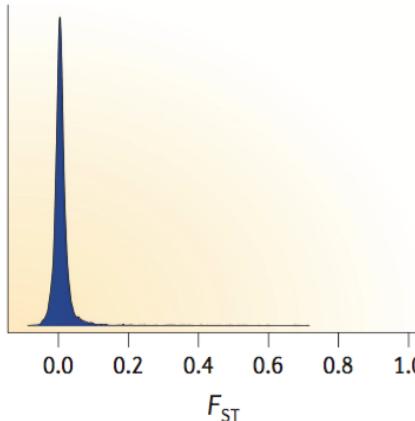
Nosil et al (2009) **Mol Ecol**



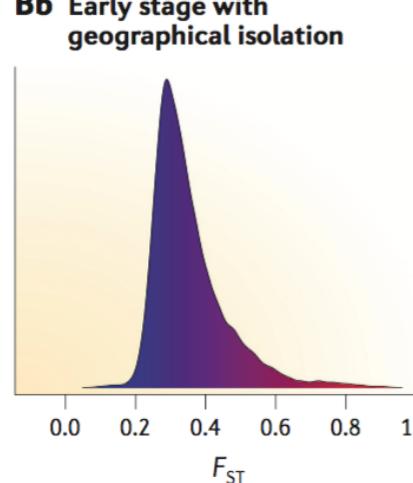
Feder et al (2012) **Trends in Genetics**

Continuums and islands

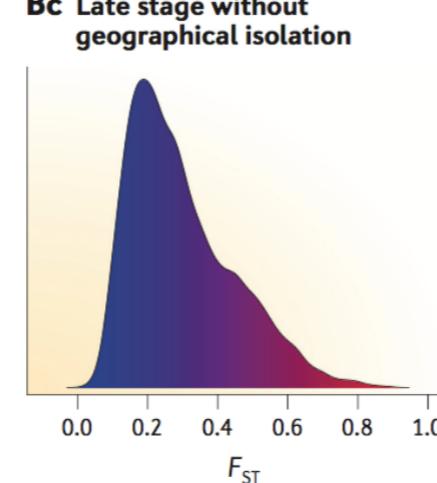
Ba Early stage without geographical isolation



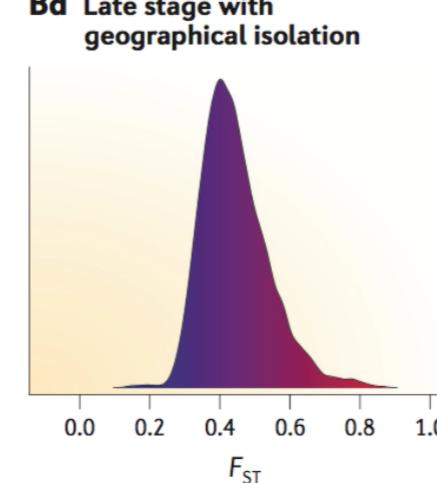
Bb Early stage with geographical isolation



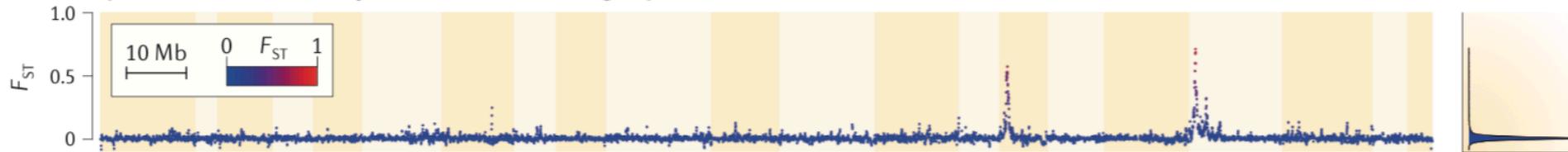
Bc Late stage without geographical isolation



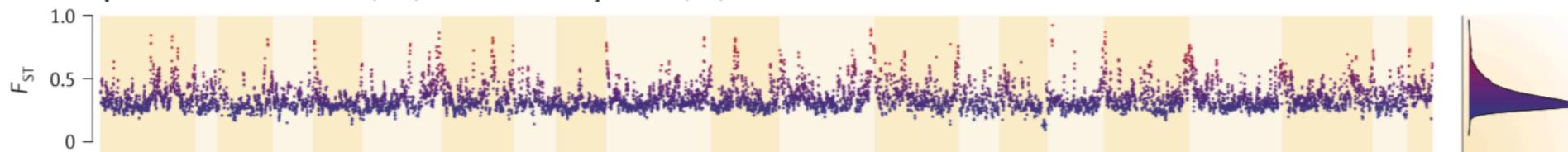
Bd Late stage with geographical isolation



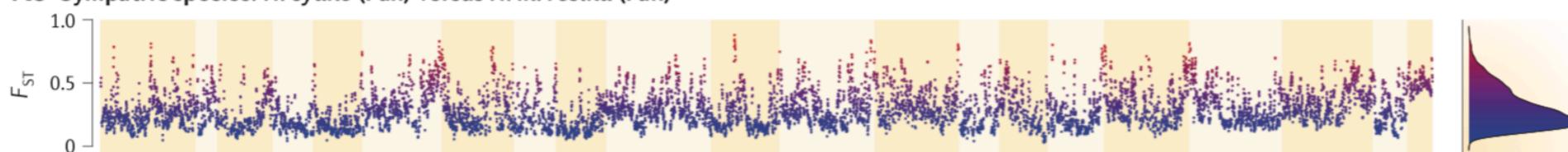
Aa Parapatric races: *H. m. amaryllis* (Per) versus *H. m. aglaope* (Per)



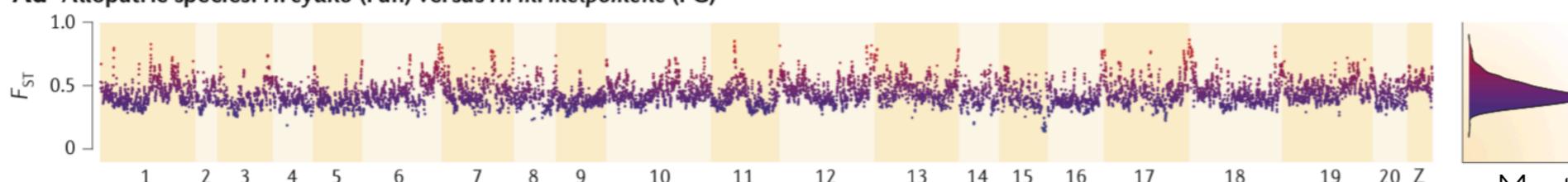
Ab Allopatric races: *H. m. rosina* (Pan) versus *H. m. melpomene* (FG)



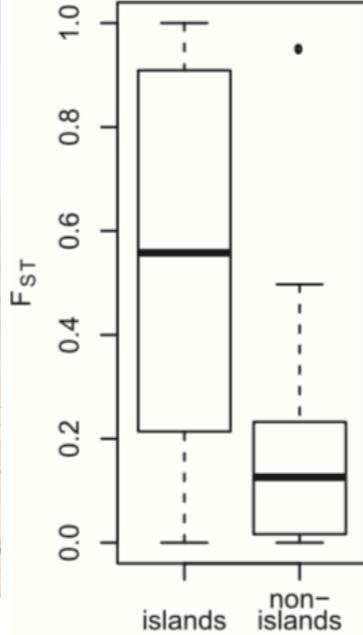
Ac Sympatric species: *H. cydno* (Pan) versus *H. m. rosina* (Pan)



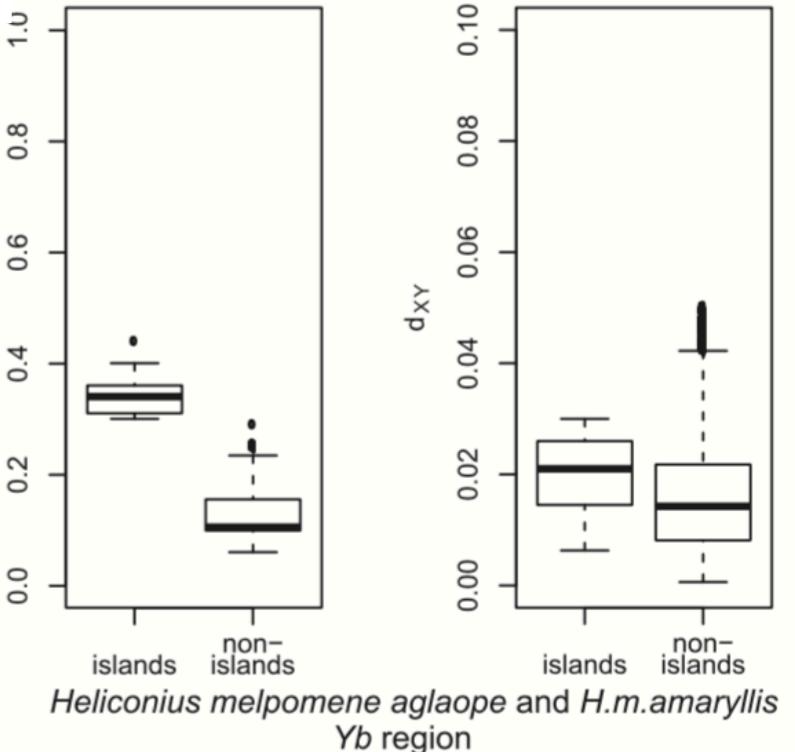
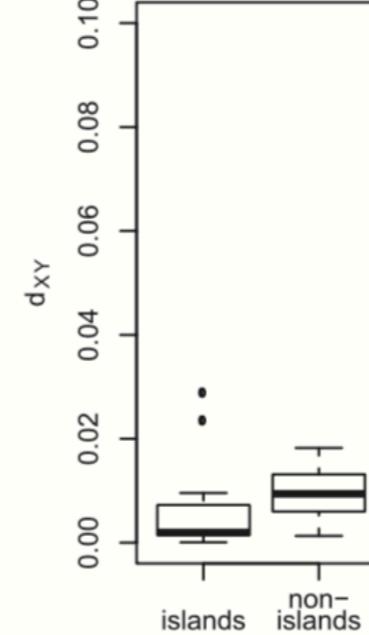
Ad Allopatric species: *H. cydno* (Pan) versus *H. m. melpomene* (FG)



Mirages and alternative explanations



Anopheles coluzzii and *A. gambiae*

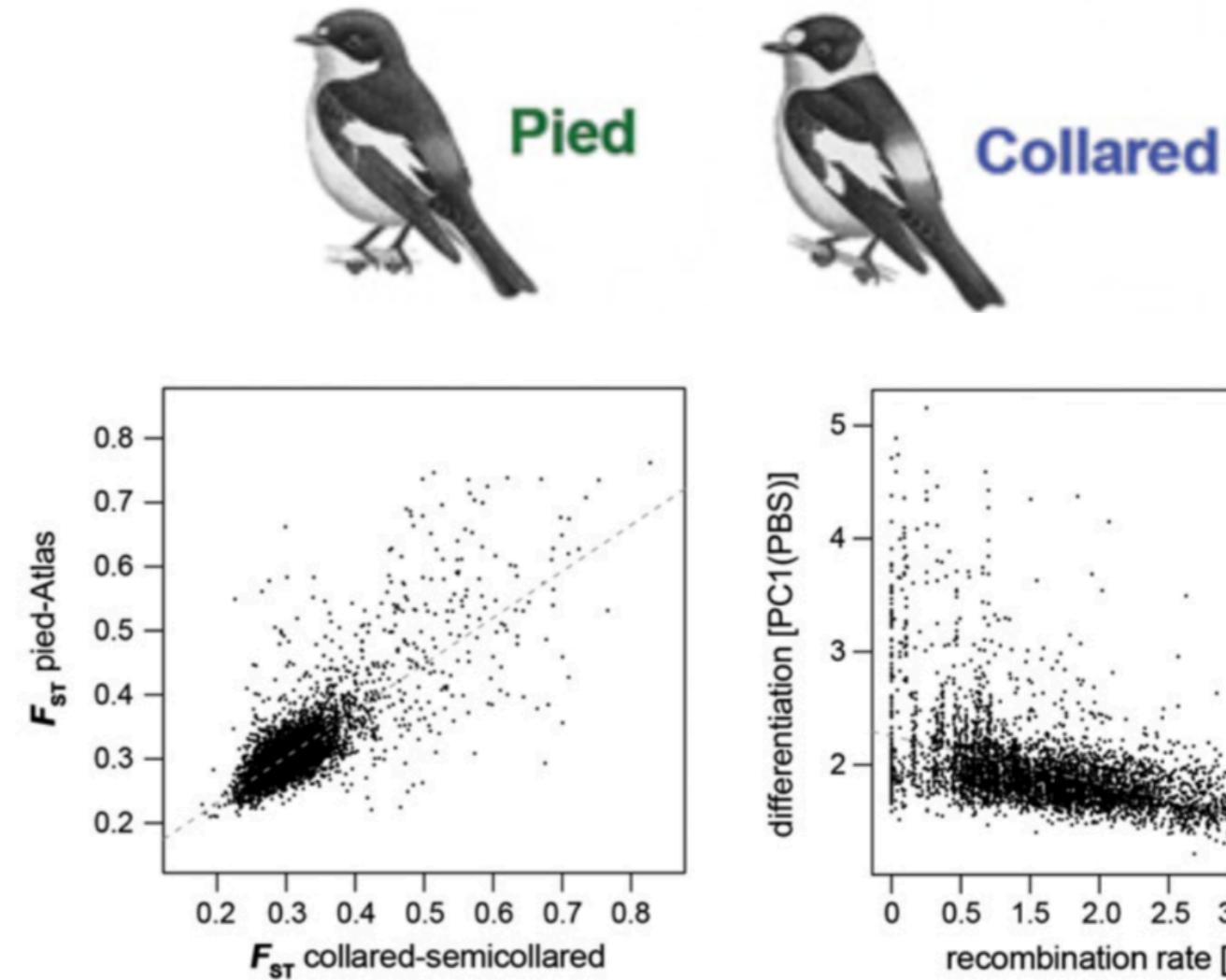
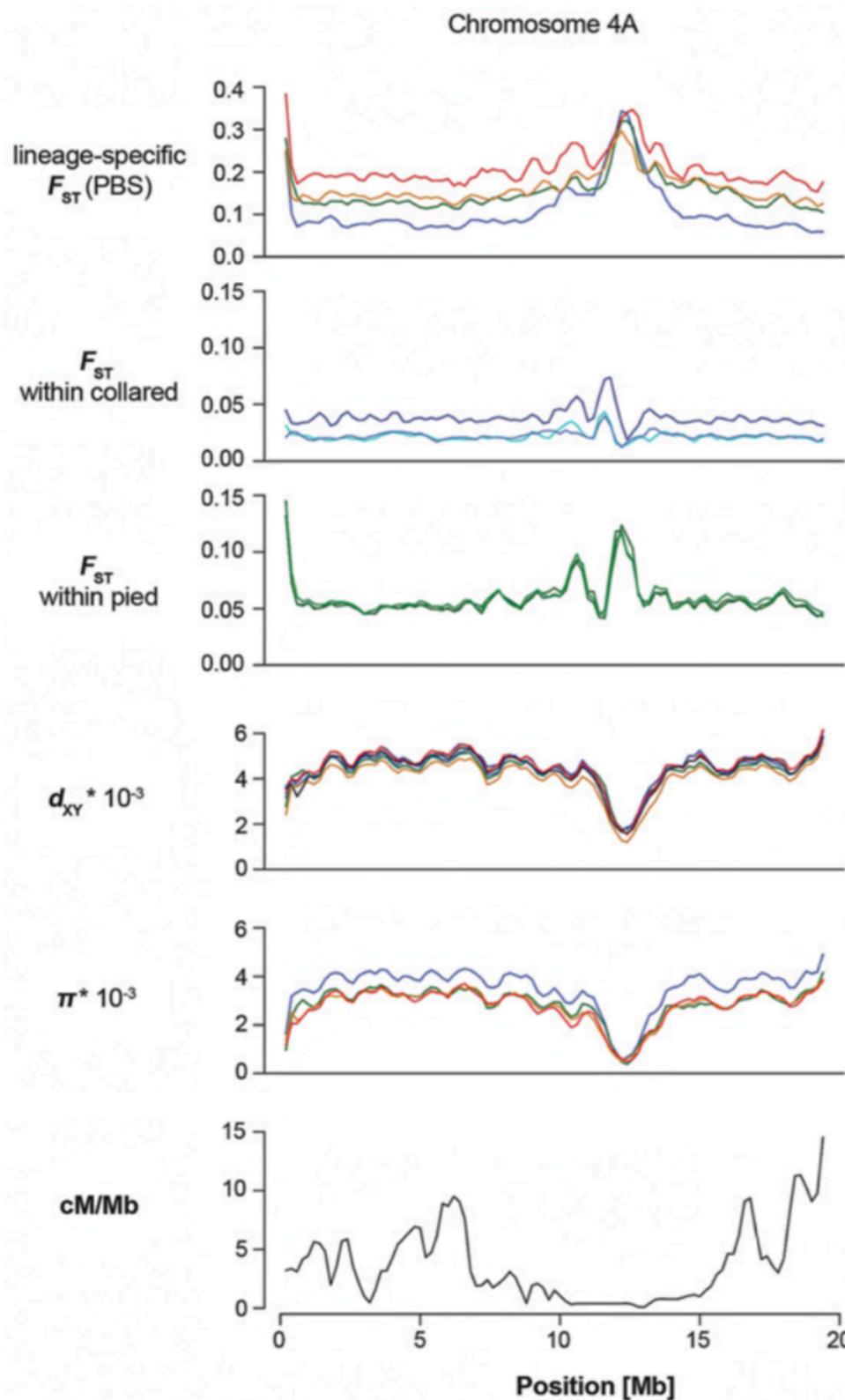


Heliconius melpomene aglaope and *H.m. amaryllis*
Yb region

- Background selection
- Local adaptation after isolation
- Shared ancestral polymorphism

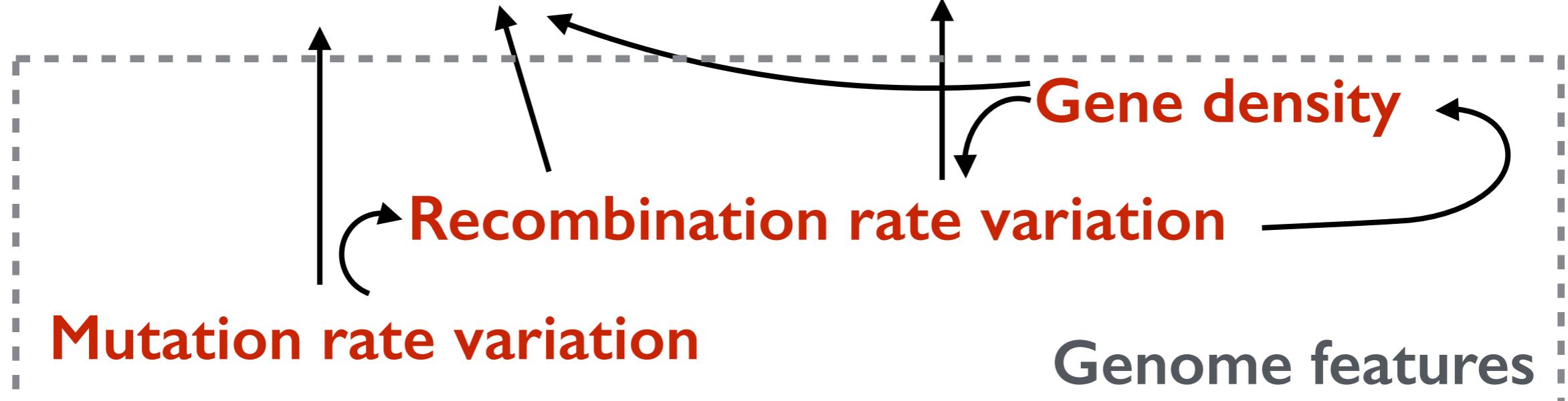
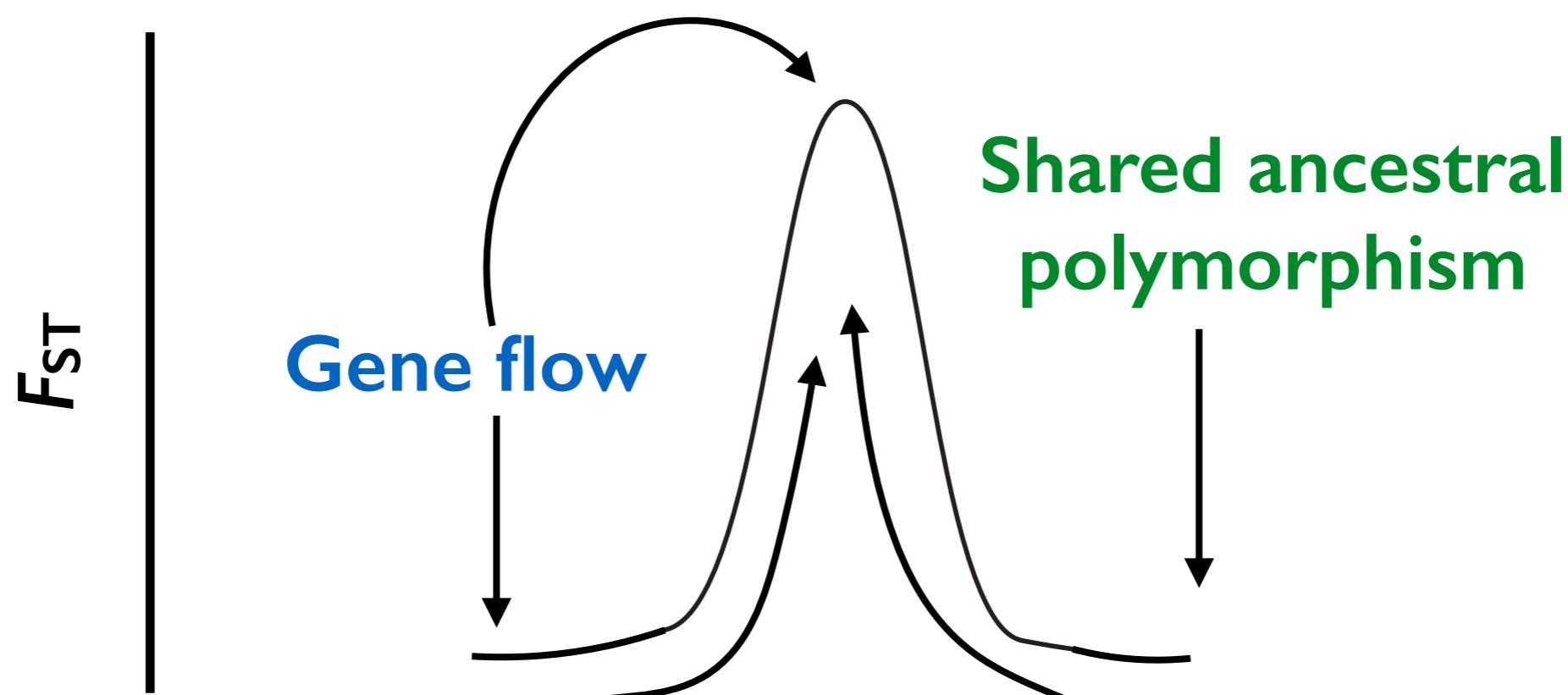
Noor & Bennett (2008) **Heredity**
Cruickshank & Hahn (2014) **Mol Ecol**

Linked selection and recombination

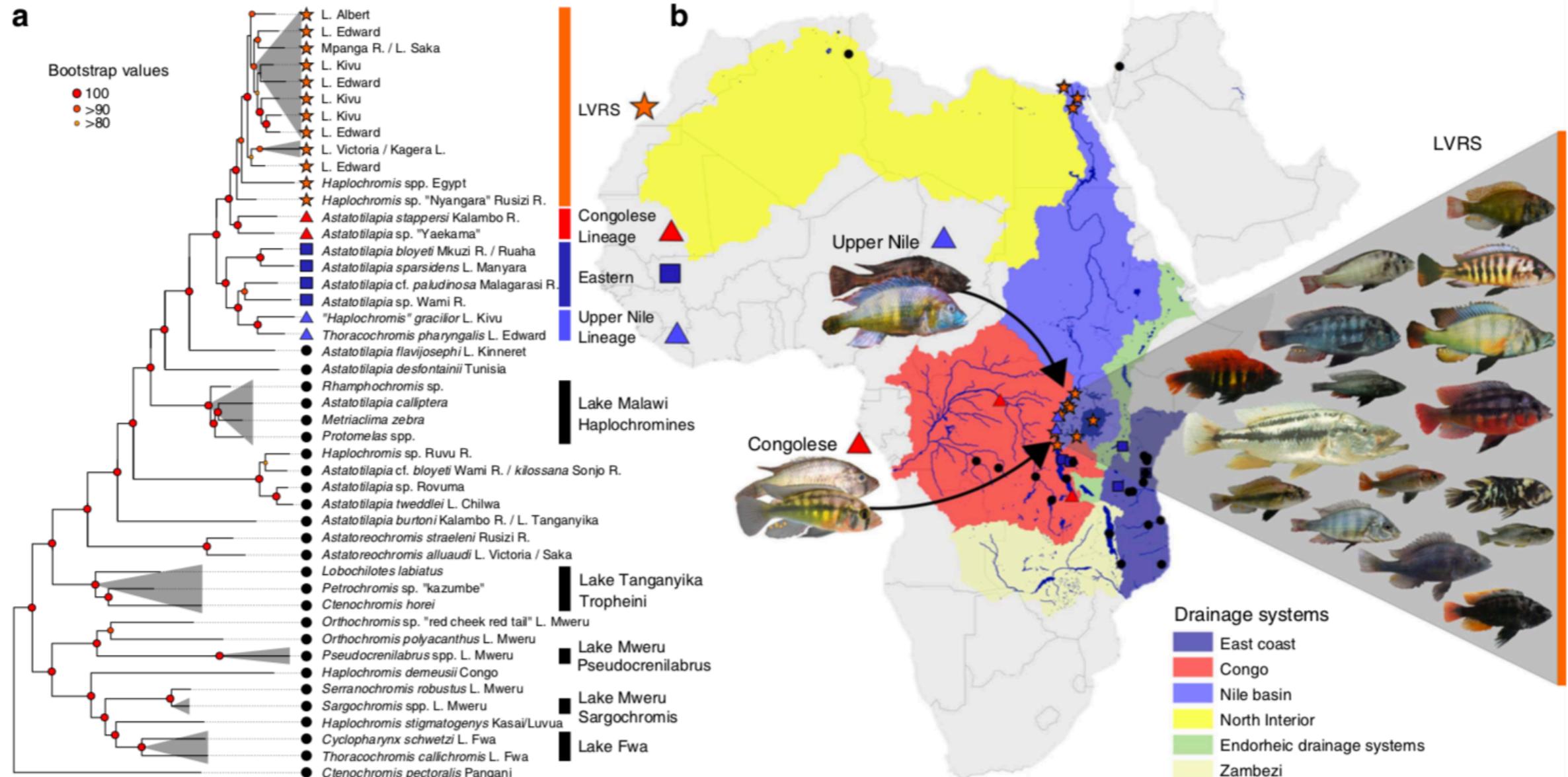


Confounding factors

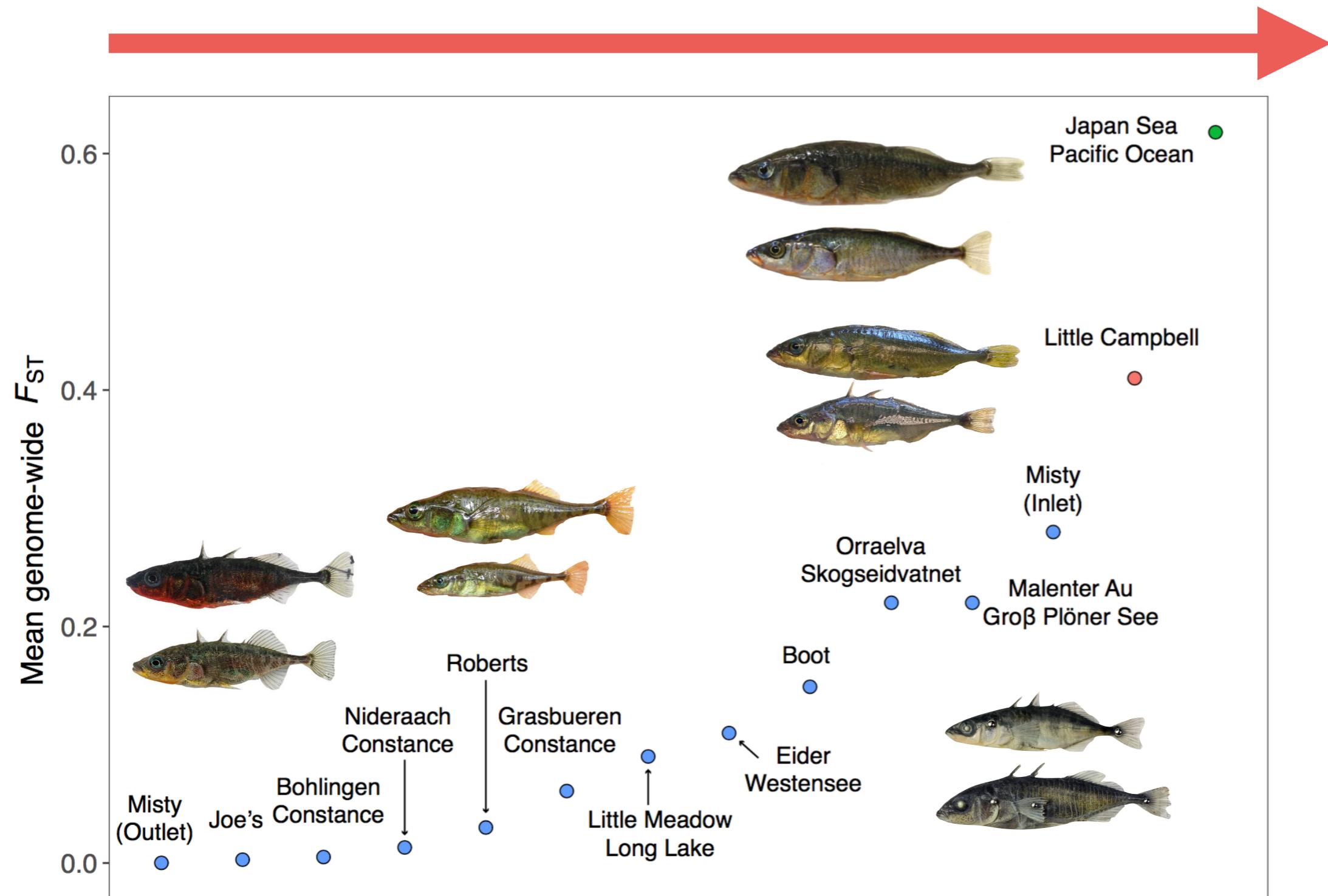
Demographic history



The Lake Victoria cichlid radiation



The stickleback speciation continuum



Roesti et al (2012) **Mol Ecol**

Roesti et al (2015) **Nat Comm**

Ravinet et al (2018) **PloS Genetics**

Rank order

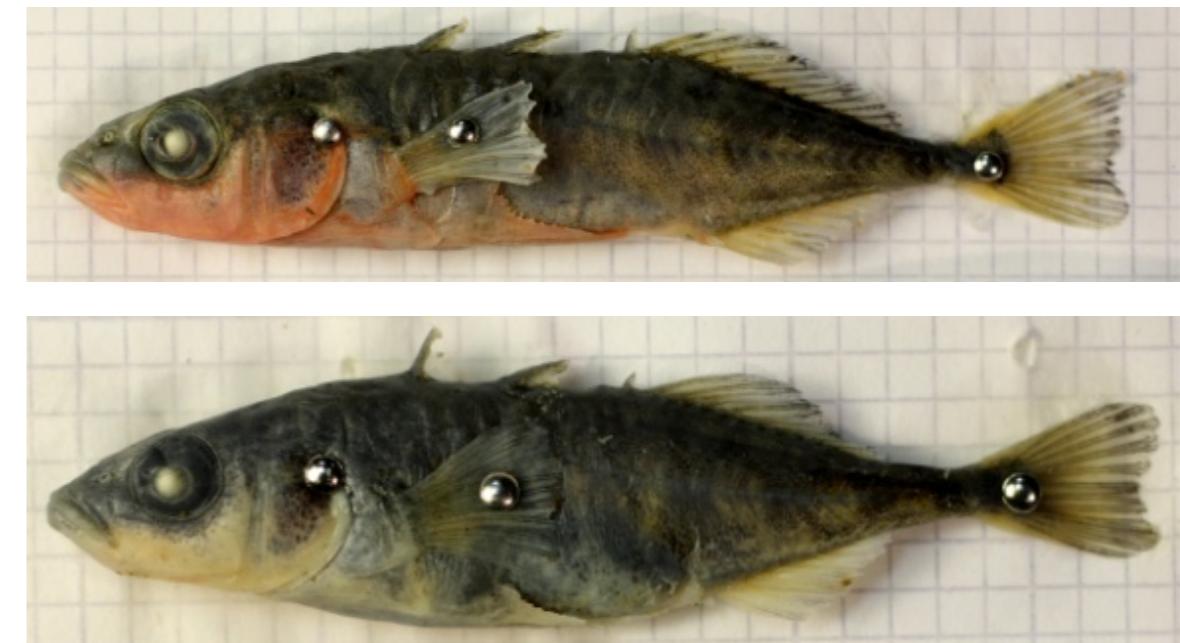
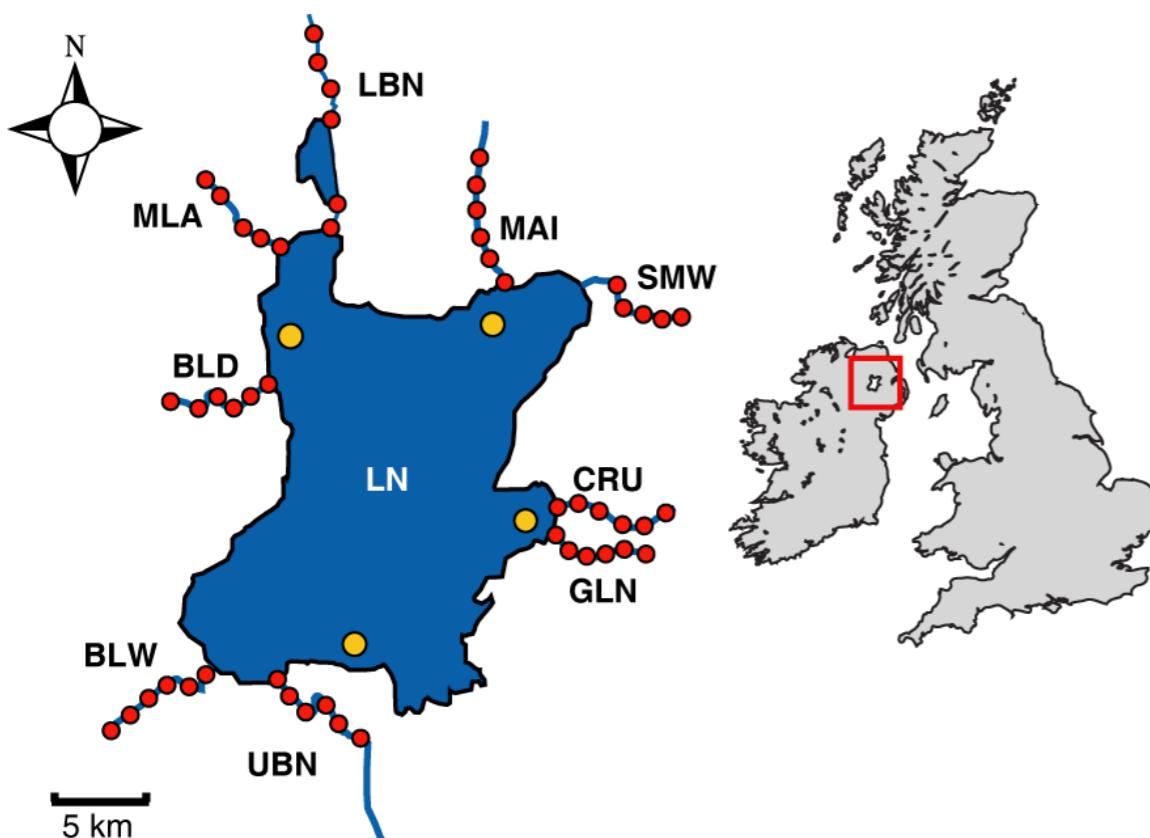
● Anadromous-stream ● Japanese ● Lake-stream

Feulner et al (2015) **PloS Genetics**

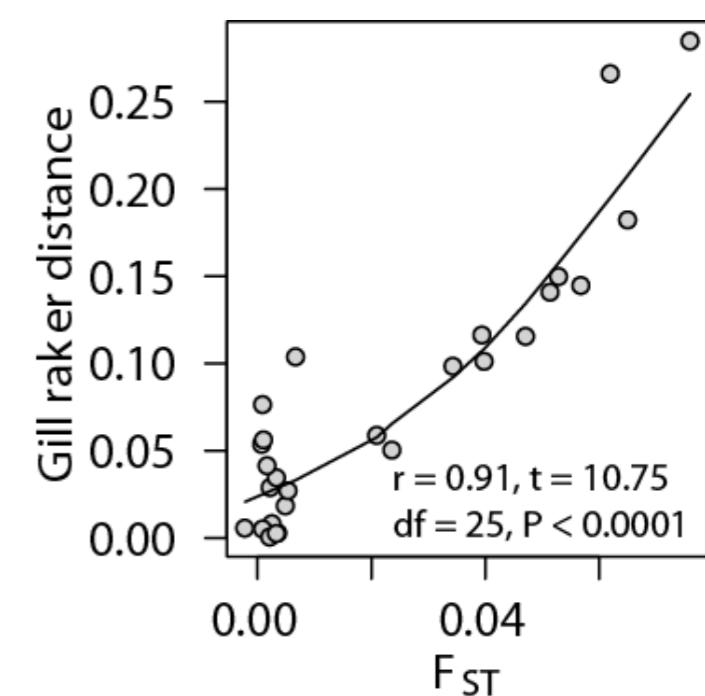
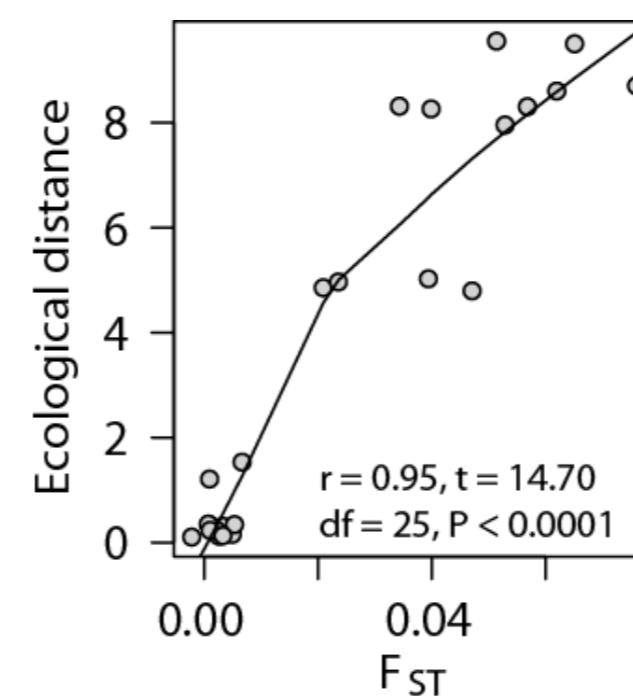
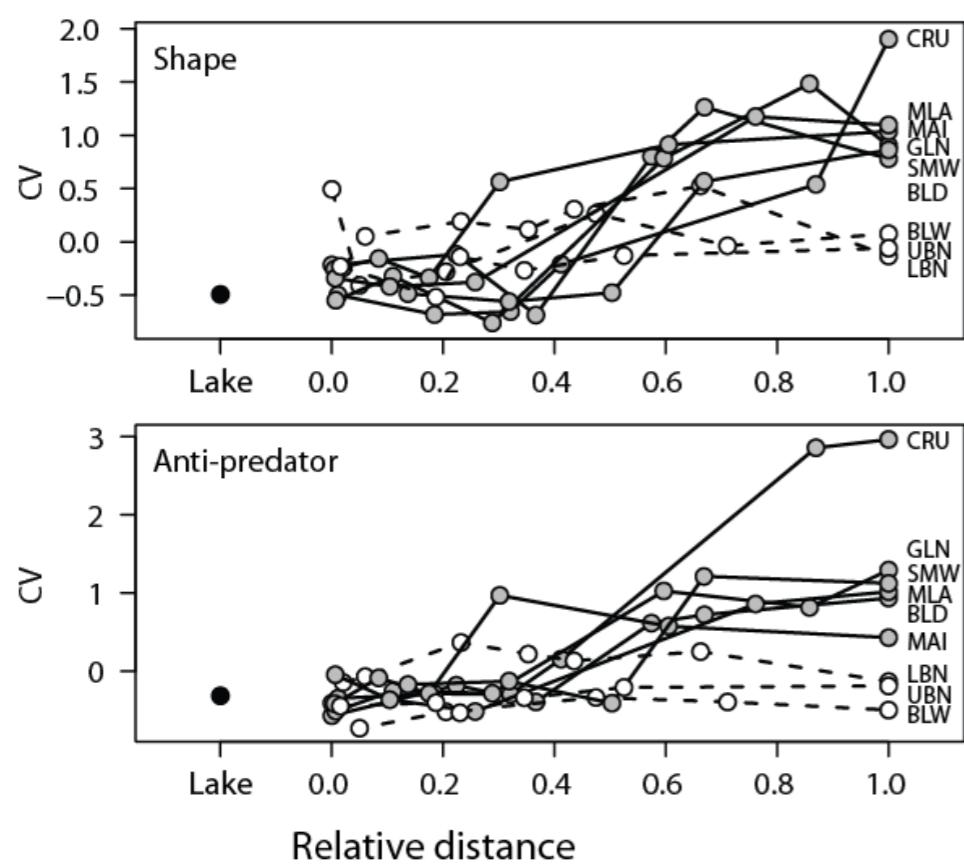
Kusukabe et al (2017) **Mol Ecol**

Marques et al (2016) **PloS Genetics**

Parallel & non-parallel lake-stream stickleback evolution



Gasterosteus aculeatus



Late stage speciation in sticklebacks



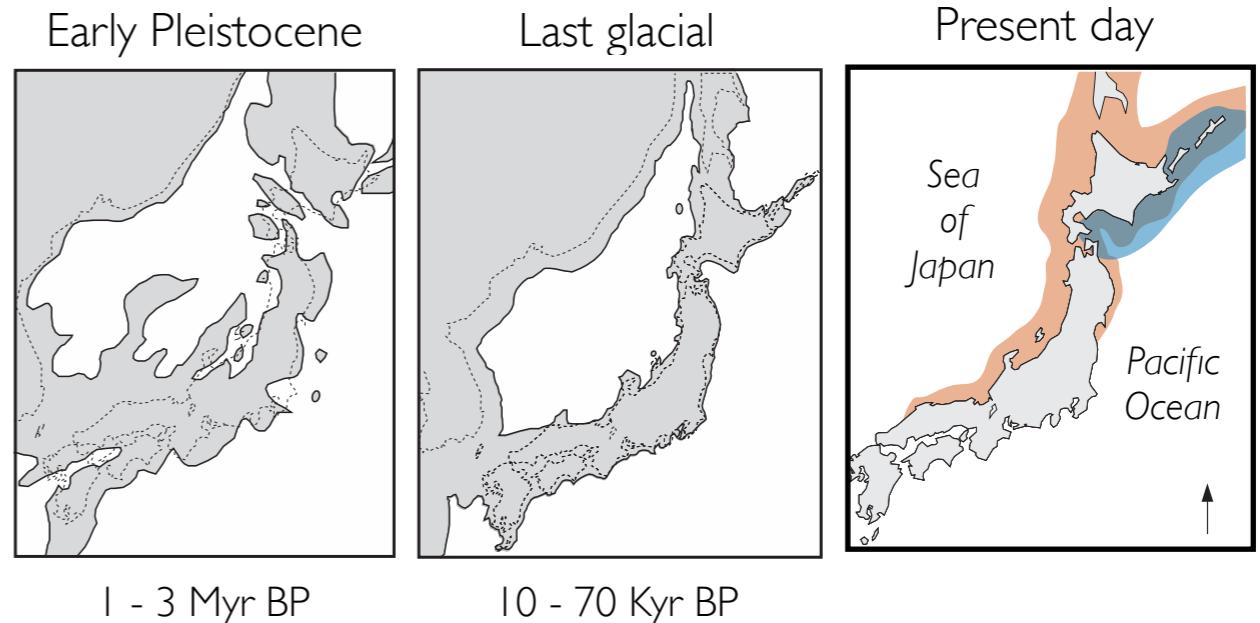
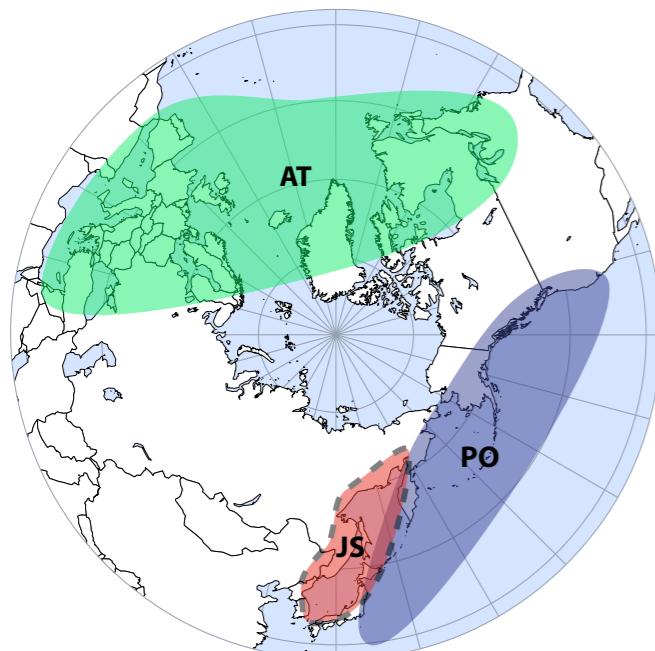
Three-spined stickleback

Pacific Ocean Atlantic Ocean

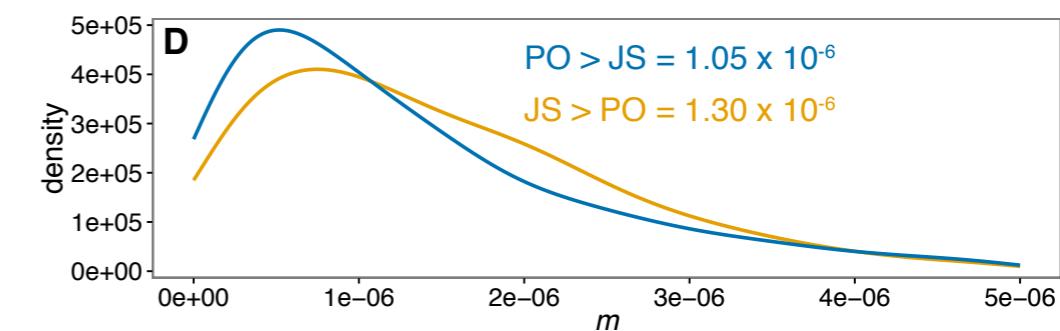
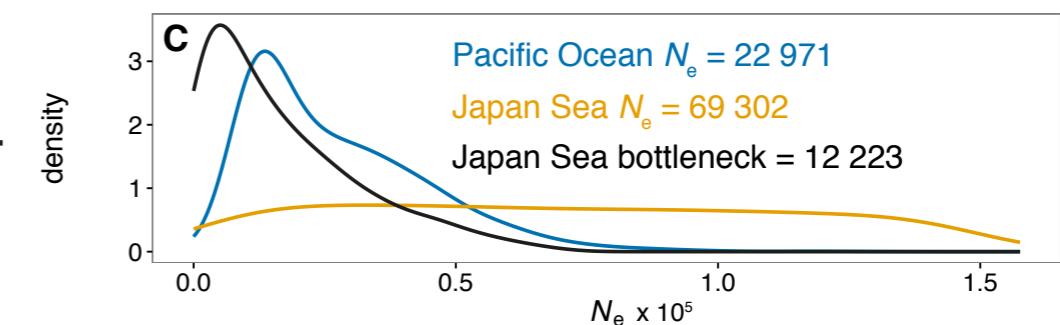
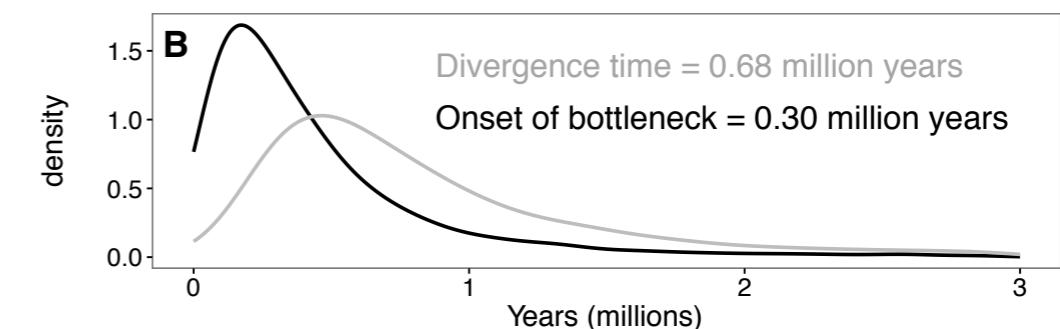
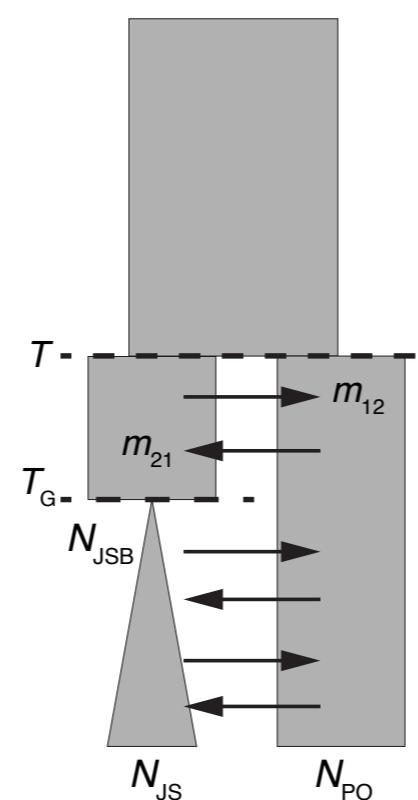


Japan Sea stickleback

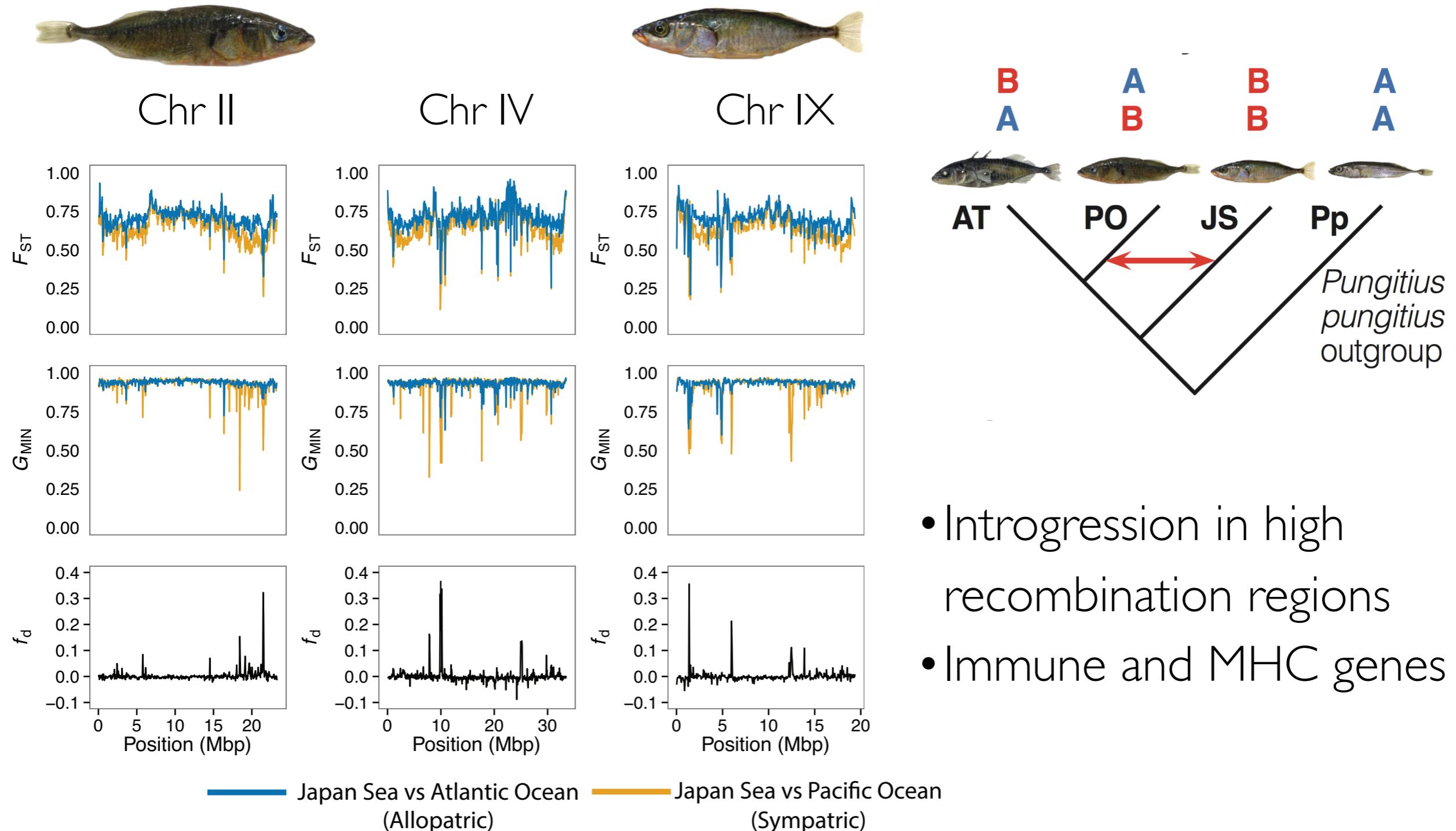
Sea of Japan Sea of Okhotsk



A Constant migration + bottleneck



Introgression localised in the genome



House sparrow

Passer domesticus



Spanish sparrow

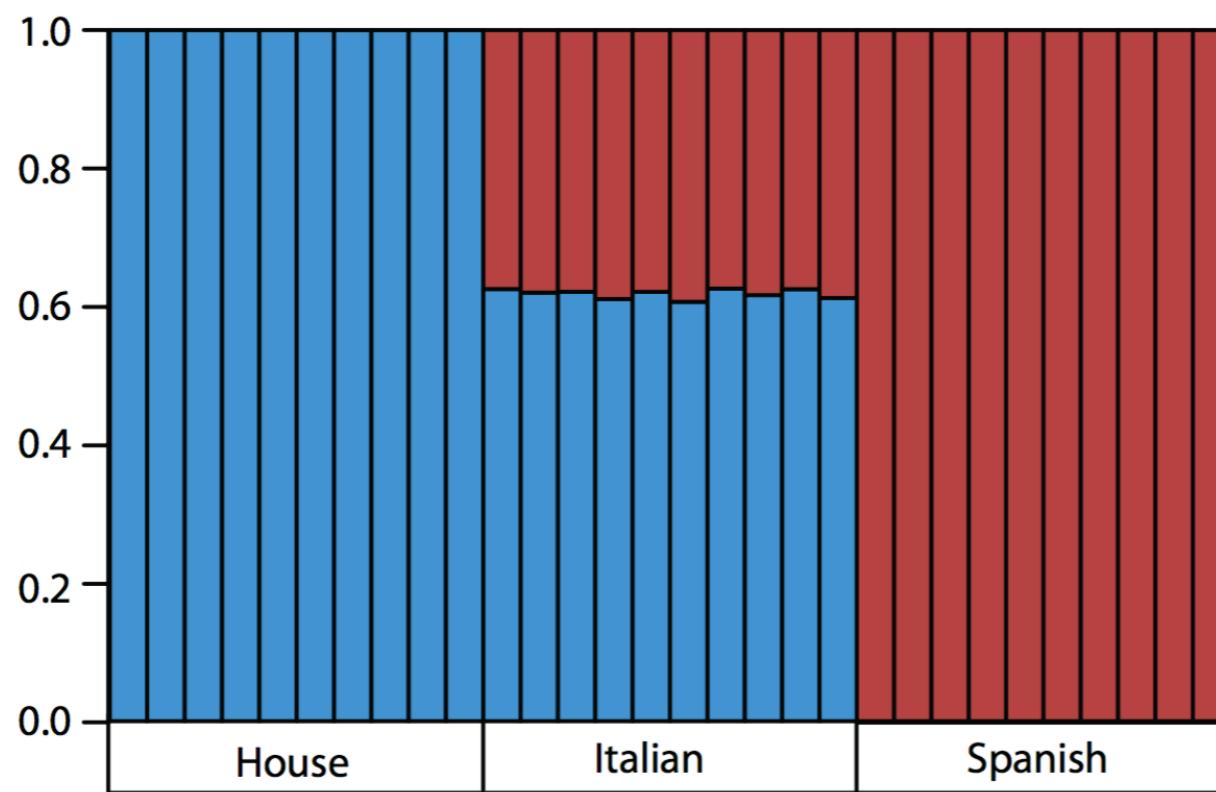
Passer hispaniolensis

Italian sparrow

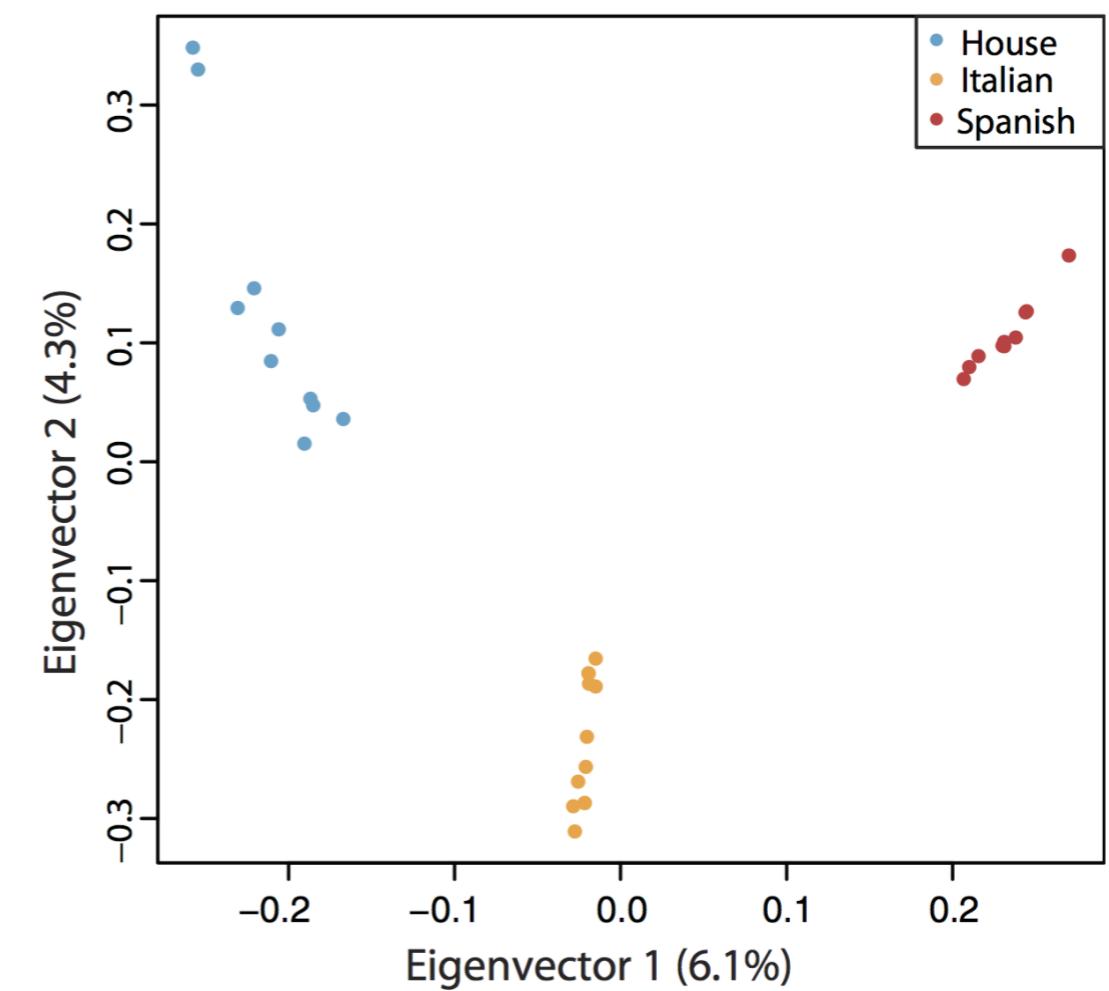
Passer italiae



Italian sparrows are a hybrid species



Analyses based on LD pruned, high quality
270 K SNPs





A confusing field - what is the way forward?



TARGET
**Inter-
findin**

Available online at www.sciencedirect.com

ScienceDirect

Current Opinion in
Genetics
& Development

Interpreting the genomic landscape of introgression

Simon H Martin and Chris D Jiggins



M. RAVINET*† , R. FARIA‡§¶, R. K. BUTLIN¶**, J. GALINDO††, N. BIEF
M. RAFAJLOVIĆ§§ , M. A. F. NOOR¶¶ , B. MEHLIG§§ & A. M. WESTR

COMMENTARY

**Parallelism in genomic
landscapes of differentiation,
conserved genomic features
and the role of linked selection**

EVIEWS

RESPONSE

**Land ahoy? Navigating the
genomic landscape of
speciation while avoiding
shipwreck**

A. M. WESTRAM*  & M. RAVINET† 

H. ELLEGREN

Making
different



Jochen B. W. Wolf¹

Interpreting differentiation landscapes
in

What is Speciation Genomics? The roles of ecology, gene
flow, and genomic architecture in the formation of species

Reto¹

C. RYAN CAMPBELL, J. W. POELSTRA and ANNE D. YODER*

What we hope to achieve

- Clarify an increasingly complex and difficult field
- Teach you the tools and approaches necessary to go from raw sequencing reads to finished analyses
- Teach best practices - learn from our mistakes!
- Generate discussion and interaction
- Create a resource you can refer back to throughout your analyses and research

speciationgenomics.github.io

Bioinformatics secret weapons

