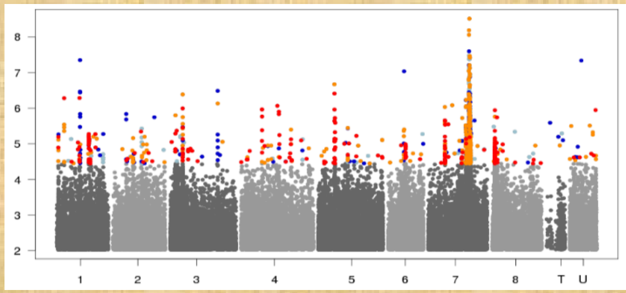
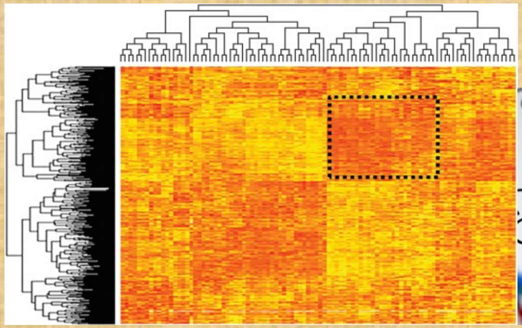
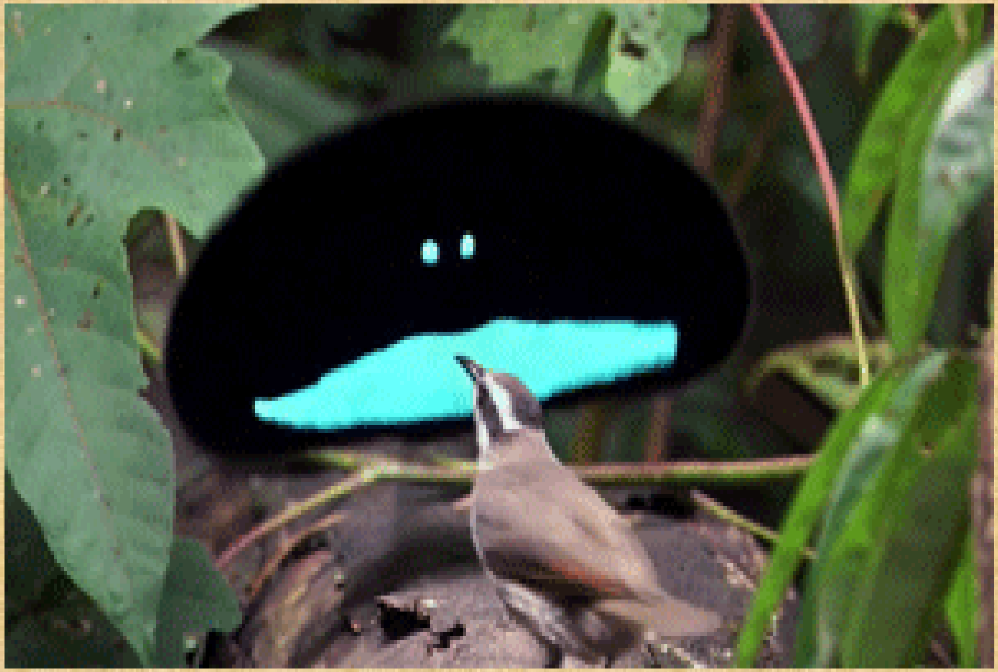
Genomics of speciation and adaptation: Sexual selection

19.02.2019, Clément Lafon Placette





Courtship traditions, sexual dimorphism: a result of sexual selection?



Very often males court, females choose

Phalaropus species

Females provide resources to/take care of the progeny

(The other way around also exists)

Plan of the lecture

Sexual selection

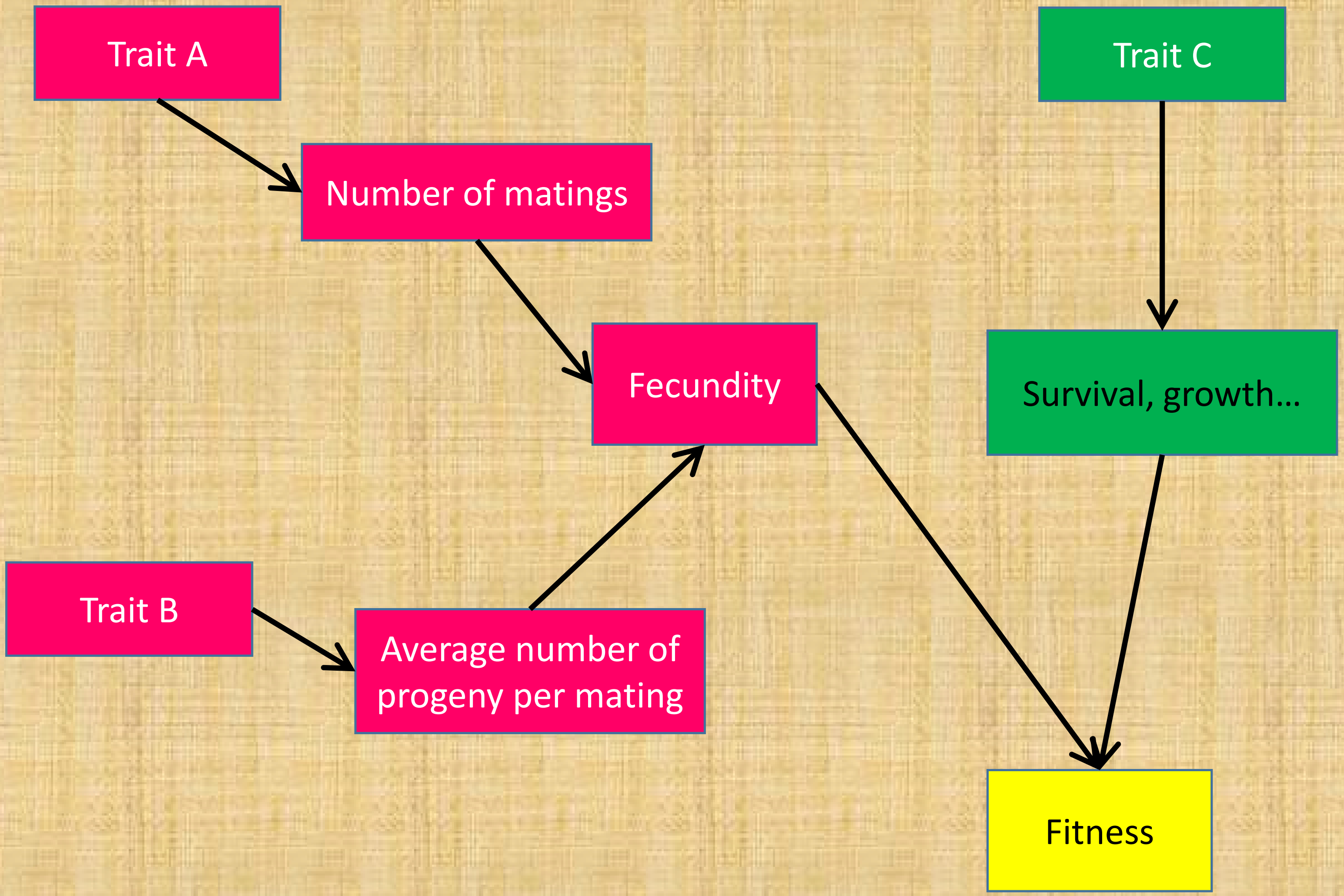
basic principles
“runaway” vs “good genes” selection
Behavioral vs gametic selection
In plants!

When SS becomes a conflict

(population) genomics consequence of SS/SC

Consequences for speciation

Behavioral isolation
Gametic isolation
Genomics of SS/SC-mediated speciation
Genomics of SS mediated speciation: not always genetic cause/basis



Moore and Pannell, 2011

Sexual selection: basic principle

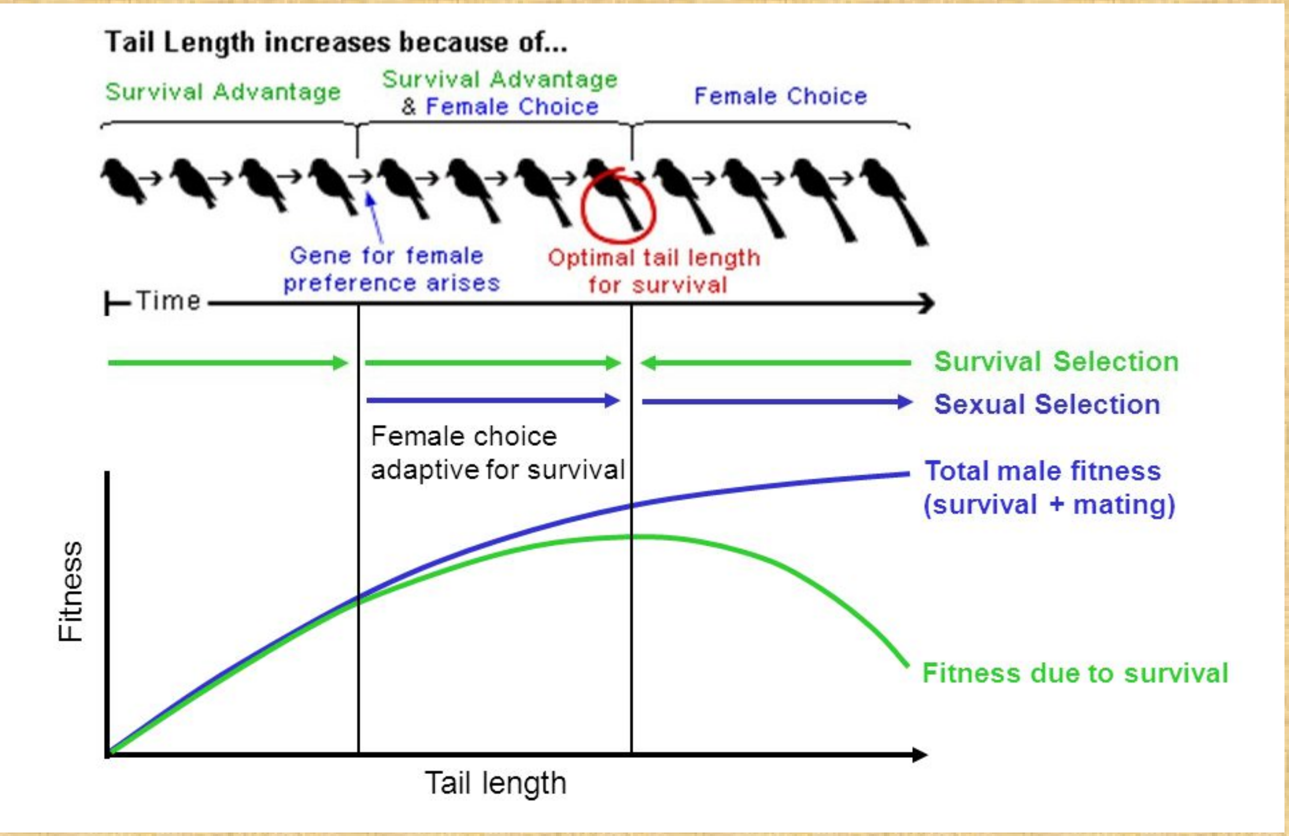
Mating is a limited event
→ Competition for such

Biased sex ratios may exacerbate the process, but is not necessary

The sex taking care of/bringing the resources to the progeny:
advantage of selecting the mating partner

intrasexual competition + selection by the other sex = sexual selection

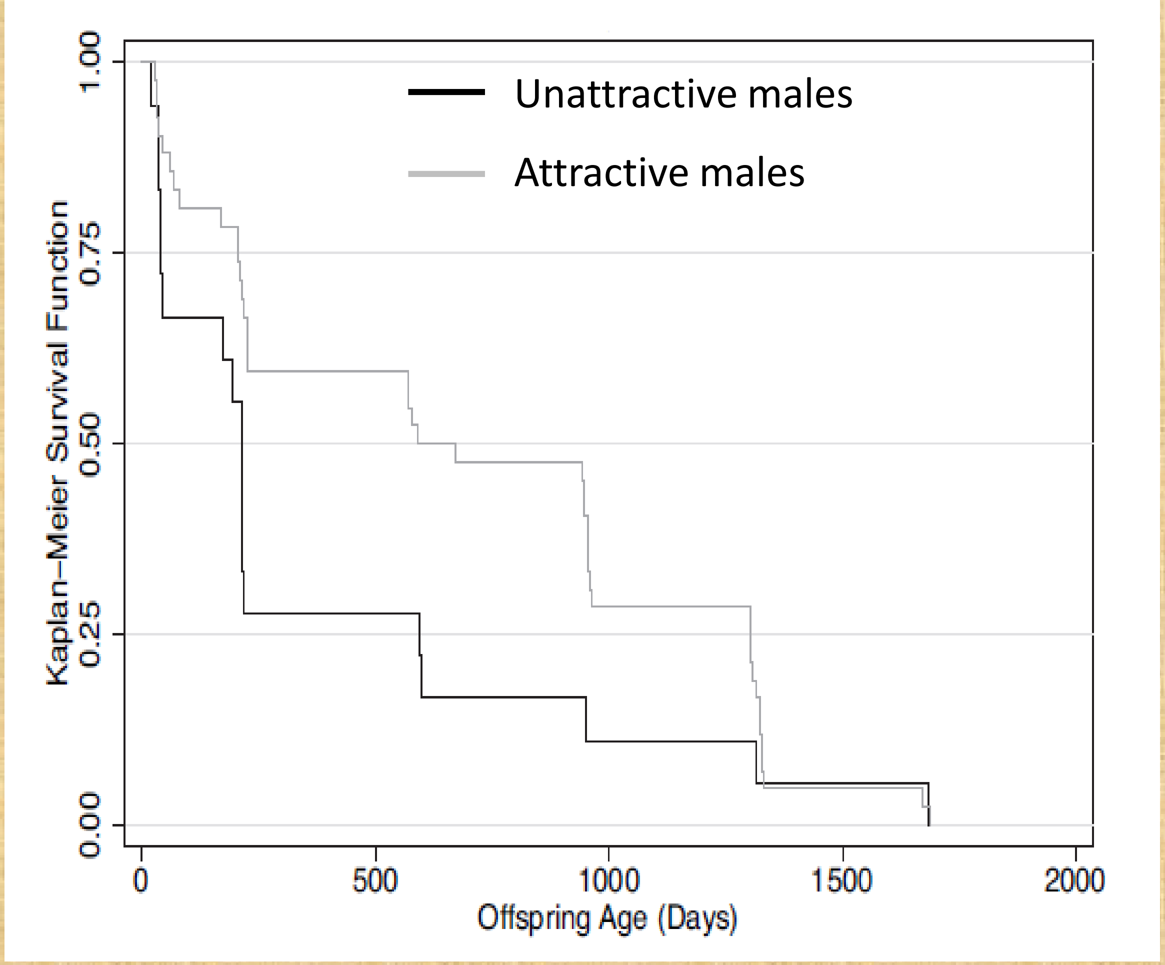
Runaway sexual selection



https://sirtyrionlannister.wordpress.com/

Antilocapra americana

Good-gene sexual selection

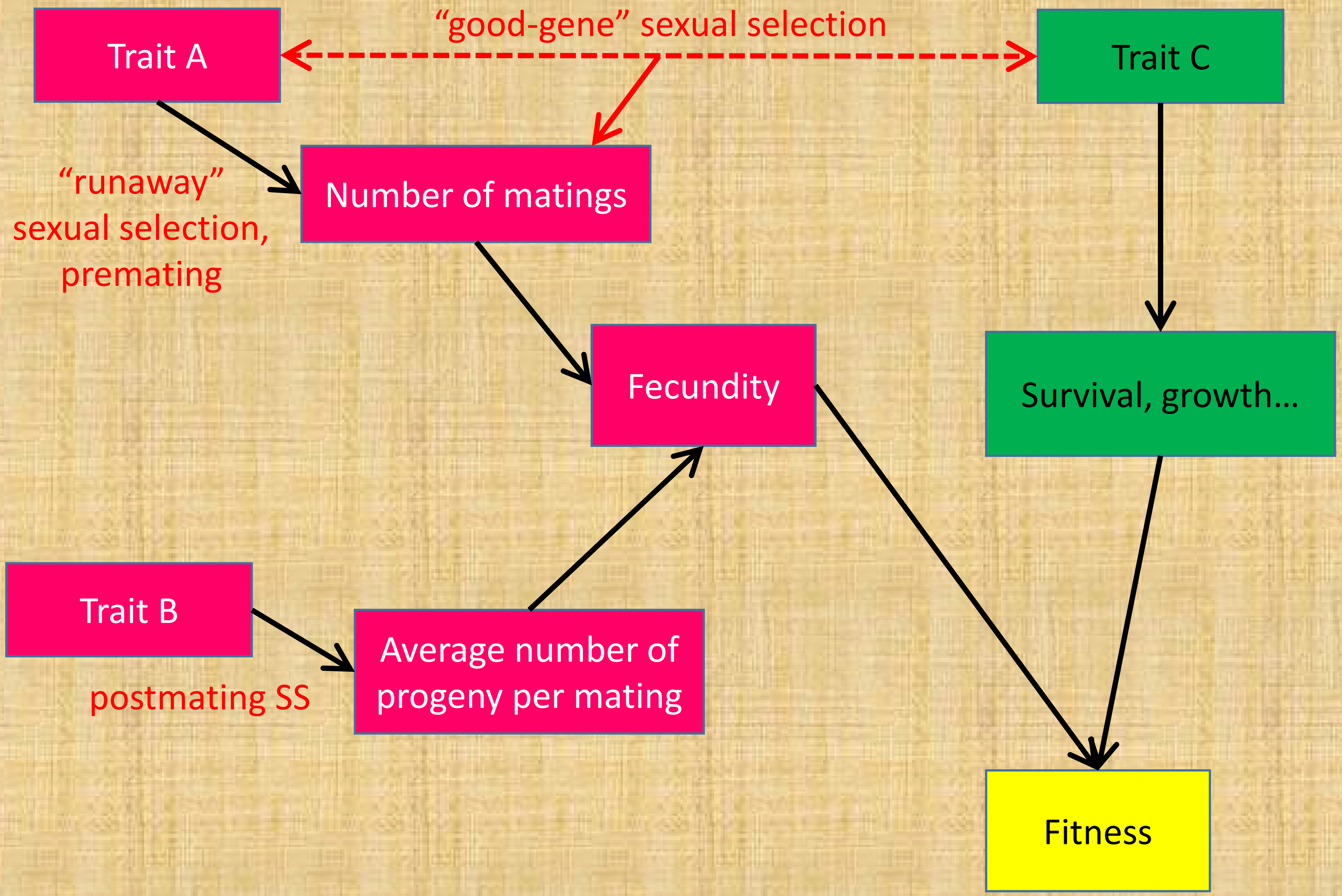


Byers and Waits, 2006

Pre vs postmating sexual selection

Premating: behavioural

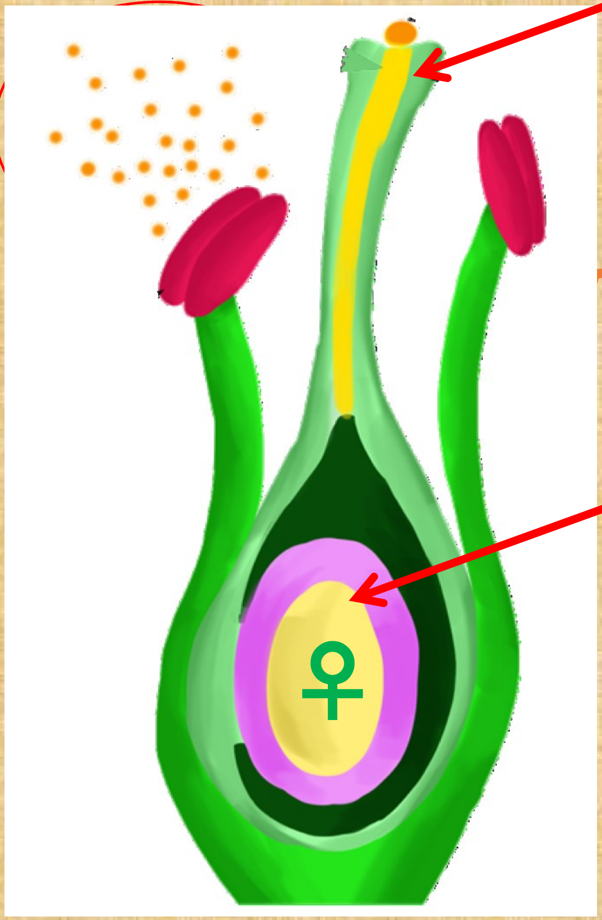
Postmating: cellular/molecular, interaction between gametes.
Cryptic (female) choice
Especially important in species with multiple mating



Moore and Pannell, 2011

Sexual selection in plants?

Pollen:ovule ratio
From 28:1 to 6000:1
→limited mating
→male competition



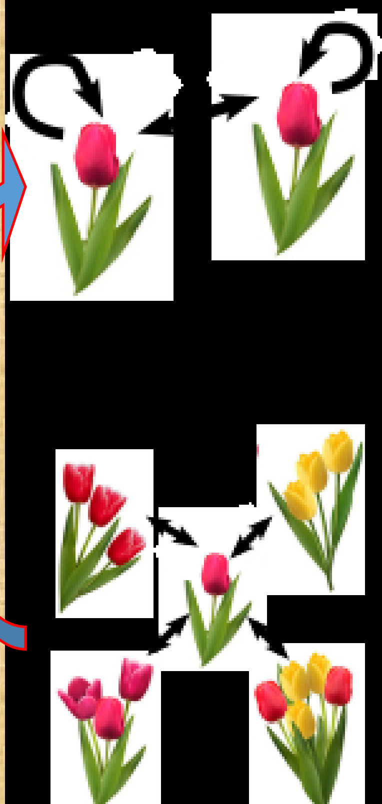
Pollen-stigma recognition
→mate selection

Pollen-ovule communication
→mate selection

Cruden, 1976

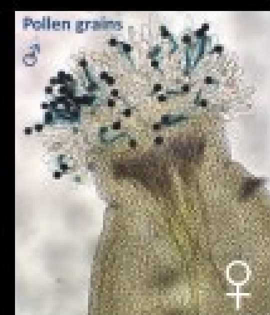
Sexual selection in plants: a convenient model

[redacted]



Frequent
in plant
evolution

Relaxed

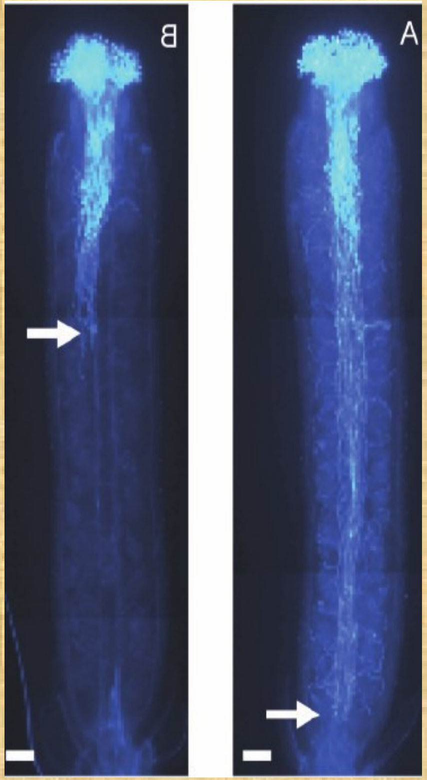


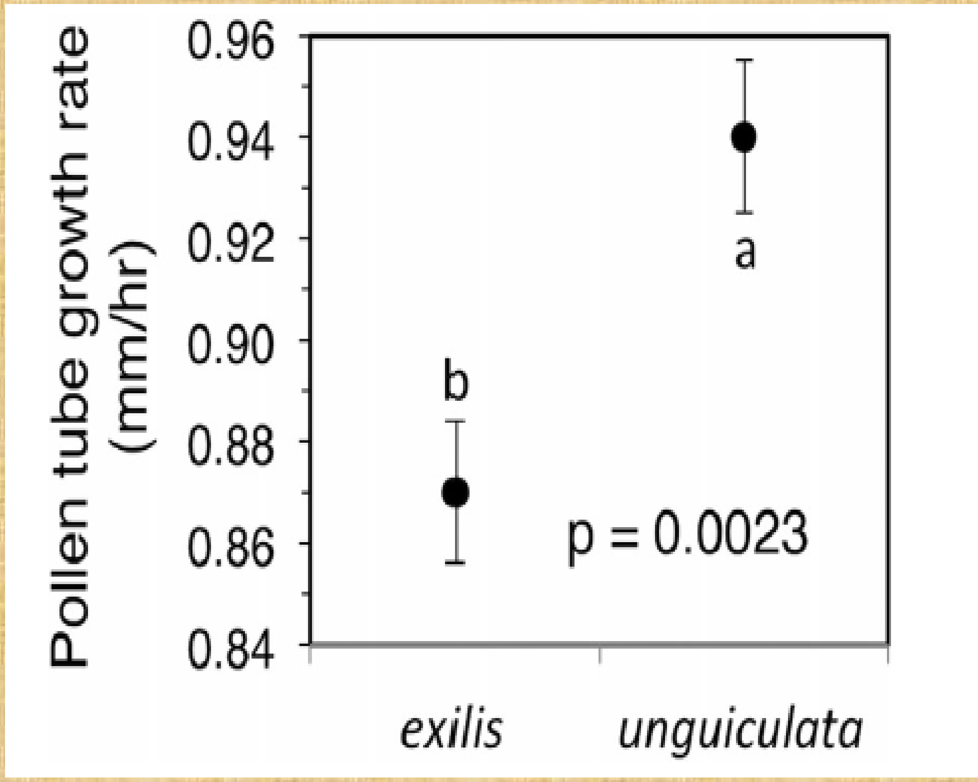
High

A trait important for sexual selection: pollen tube growth speed

Clarkia exilis, selfer

C. unguiculata, outcrosser





Mazer et al., 2018

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Behavioral isolation

Gametic isolation

Genomics of SS/SC-mediated speciation

Genomics of SS mediated speciation: not always genetic cause/basis

Sexual selection or sexual conflict?

Golden Pheasant

♀

♂

Commentary

Why aren't signals of female quality more common?

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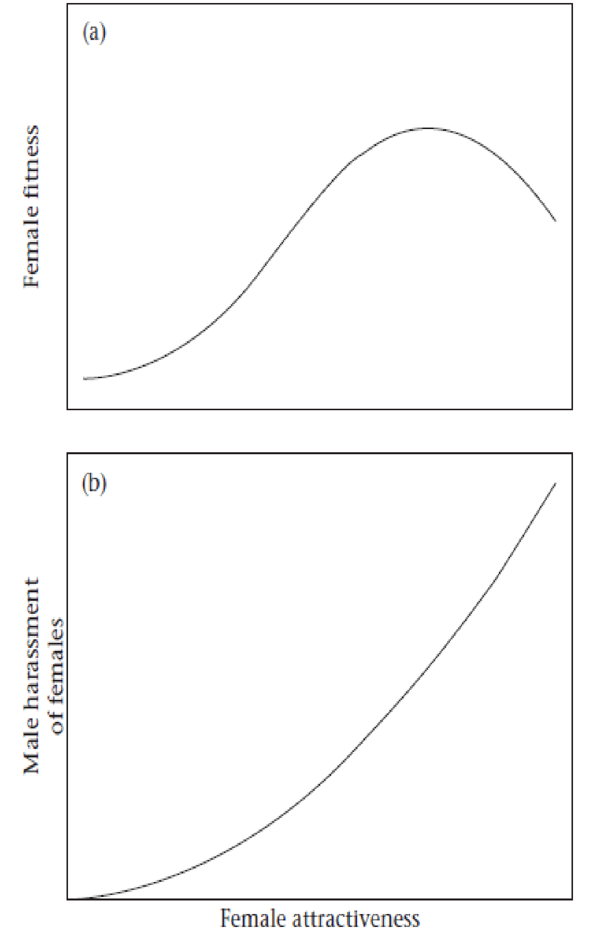
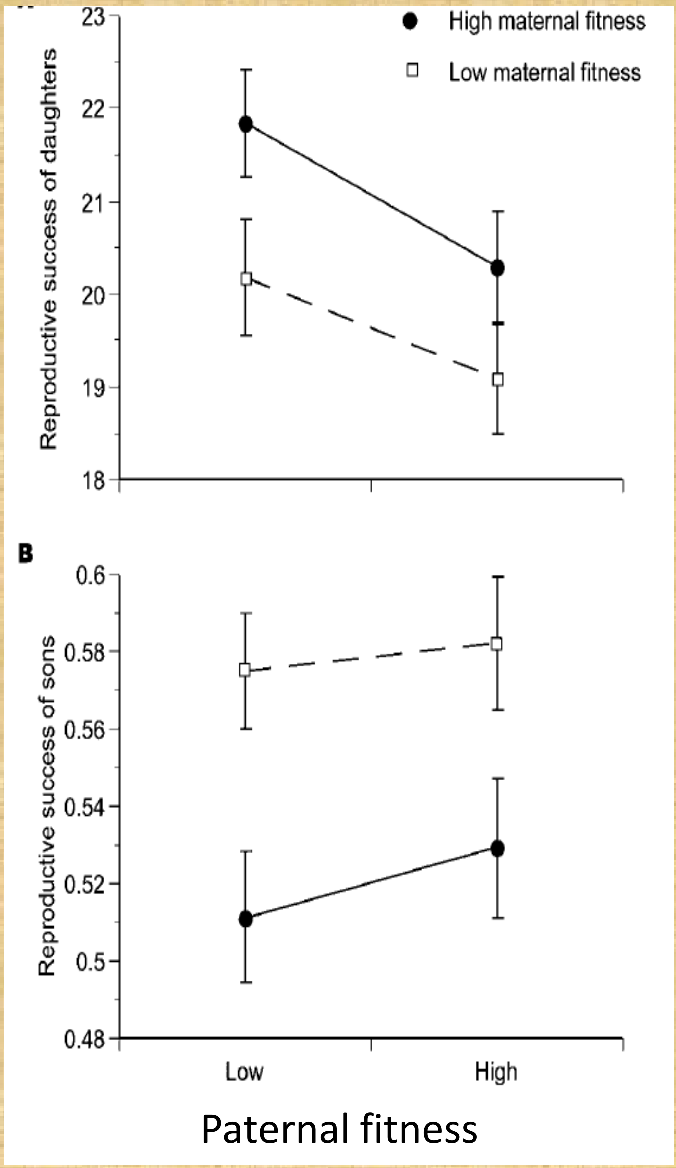


Side note: research on sexual selection is strongly linked to societal values

Sexual conflict: antagonistic selection between male and female traits



Drosophila melanogaster

Sexual conflict: when a trait that is favorable for the reproductive success of one sex and deleterious to the other

Psichedda and Chippindale, 2006

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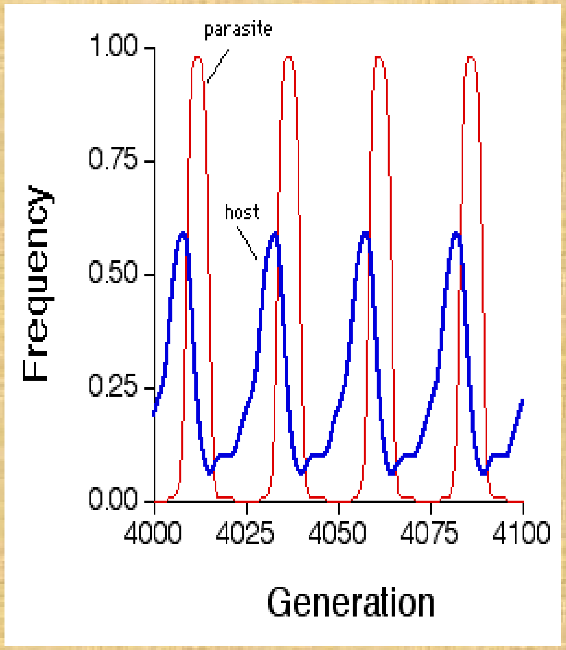
The Red Queen hypothesis

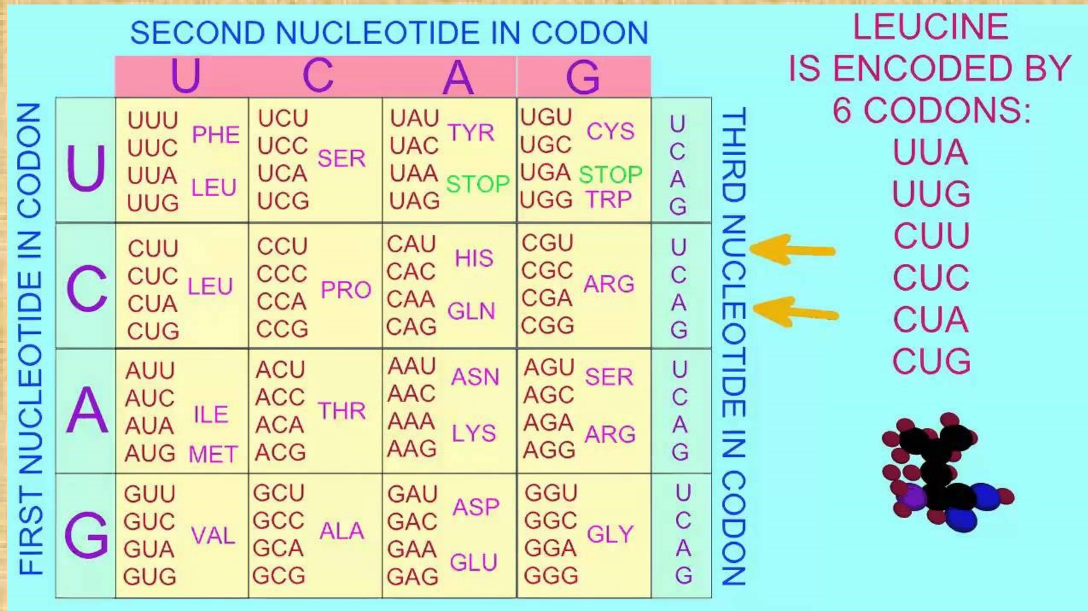
"Here, you see, it takes all the running you can do, to keep in the same place"
Lewis Carroll, *Through the Looking-Glass*



Constant adaptation/evolution to match ever-evolving (opposing) organisms

→ Applies to both sexual selection and sexual conflict
→ "arms race" = **fast evolution**
→ **coevolution** between ♂ and ♀ traits, and related genes/loci

Syn vs non syn. mutations



Synonymous: same AA encoded; non-synonymous: different AA

Ratio between syn and non-syn will tell about a given gene evolution:

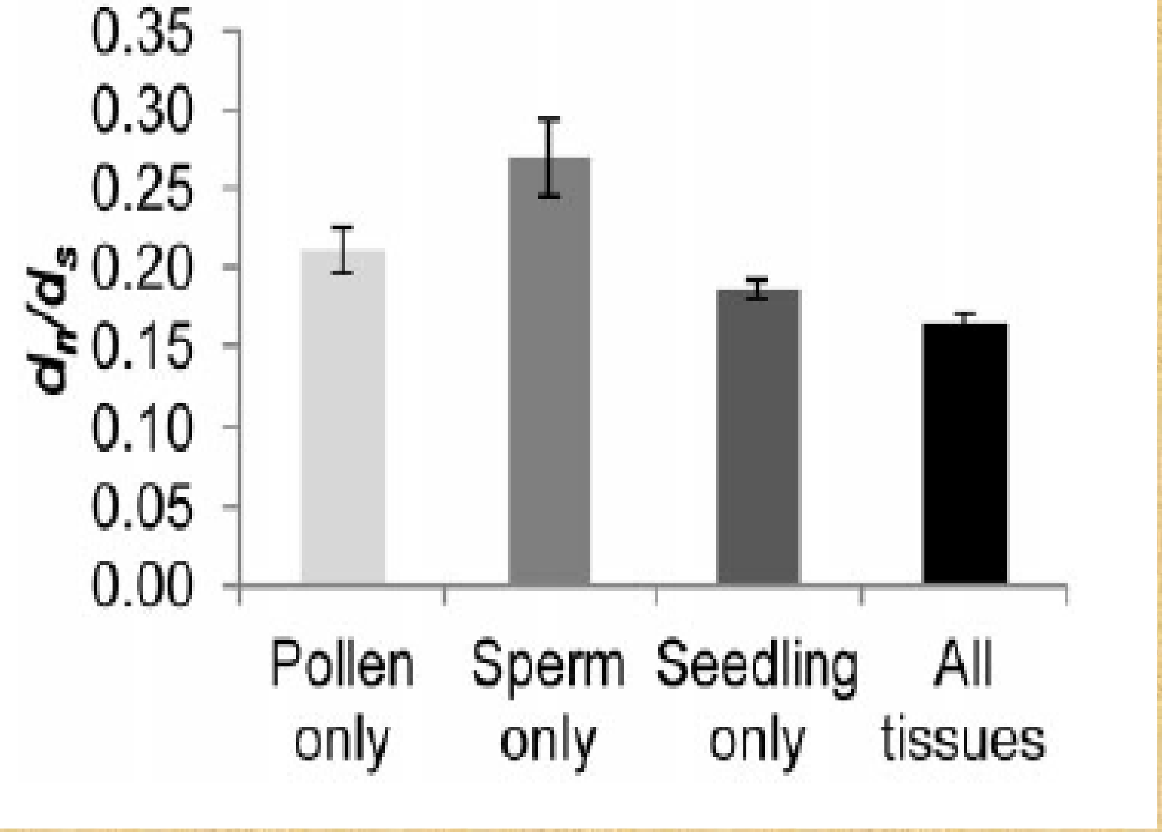
syn = "background" mutations, due to population demography, mutation rate…

non syn = important for prot function; can be purged (if deleterious) or selected (if advantageous)

A low ratio of non-syn(dN) vs syn (dS) indicates purifying selection (any mutated AA is deleterious)

A high ratio can indicate either positive selection or relaxed selection (gene with minor role)

Sexual genes evolve faster



Arunkumar et al., 2013

Plan of the lecture

Sexual selection

- basic principles
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- Behavioral vs gametic selection
- In plants!

When SS becomes a conflict

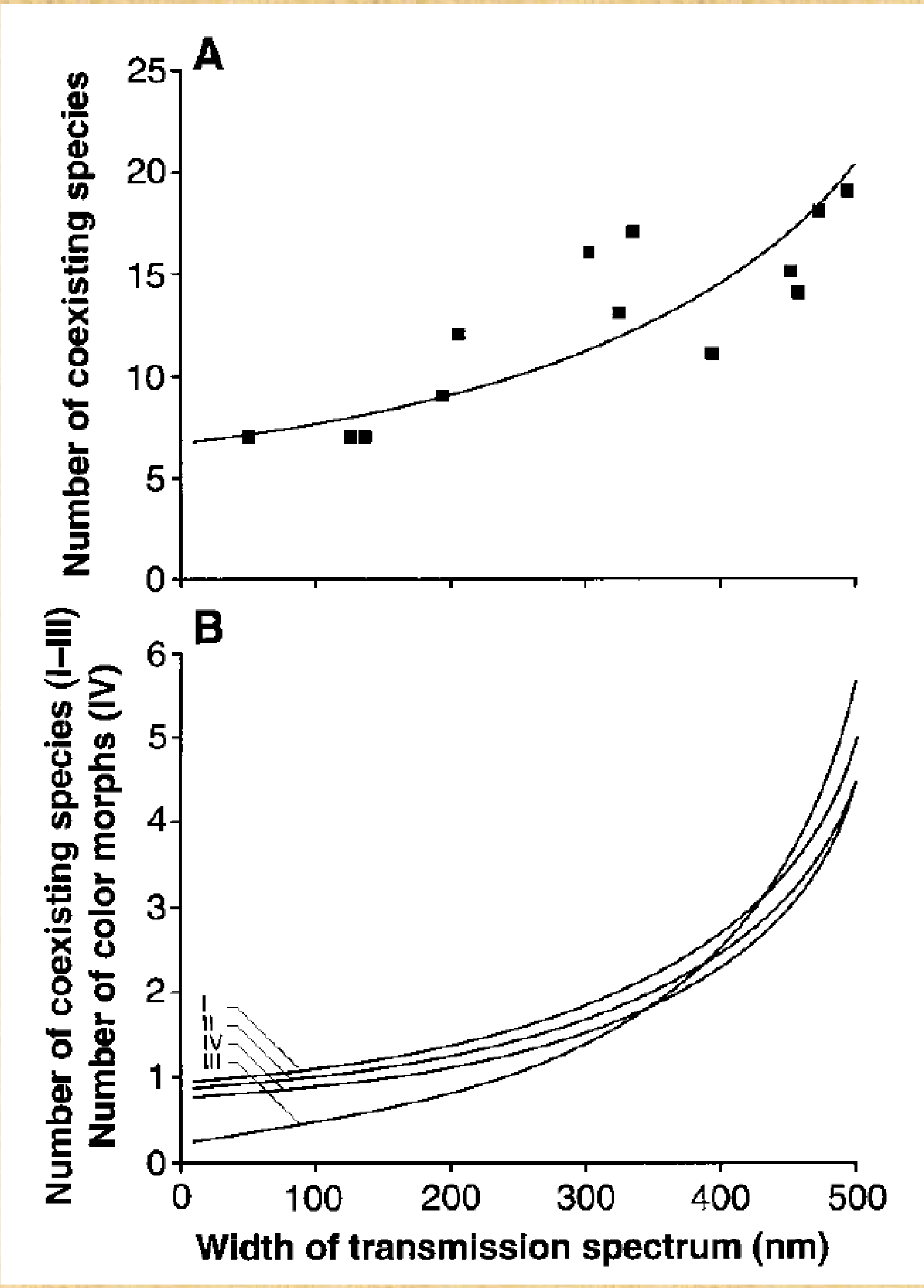
(population) genomics consequence of SS/SC

Consequences for speciation

- Behavioral isolation
- Gametic isolation
- SC-driven postzygotic barrier
- Genomics of SS/SC-mediated speciation
- Genomics of SS mediated speciation: not always genetic cause/basis

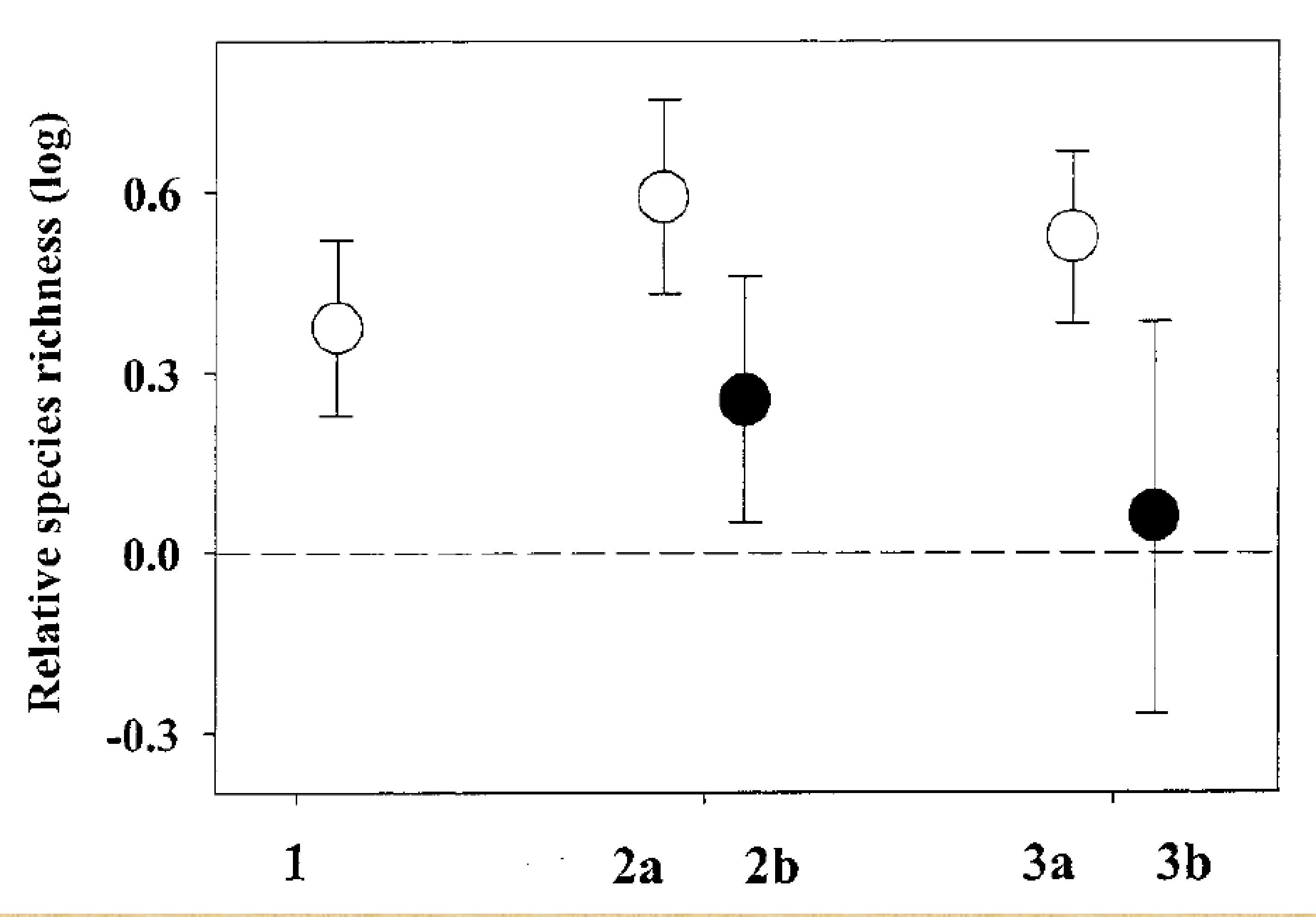
Group 1

The less spectrum available, the lower species richness



Seehausen et al., 1997

In polyandrous clades, species richness is higher



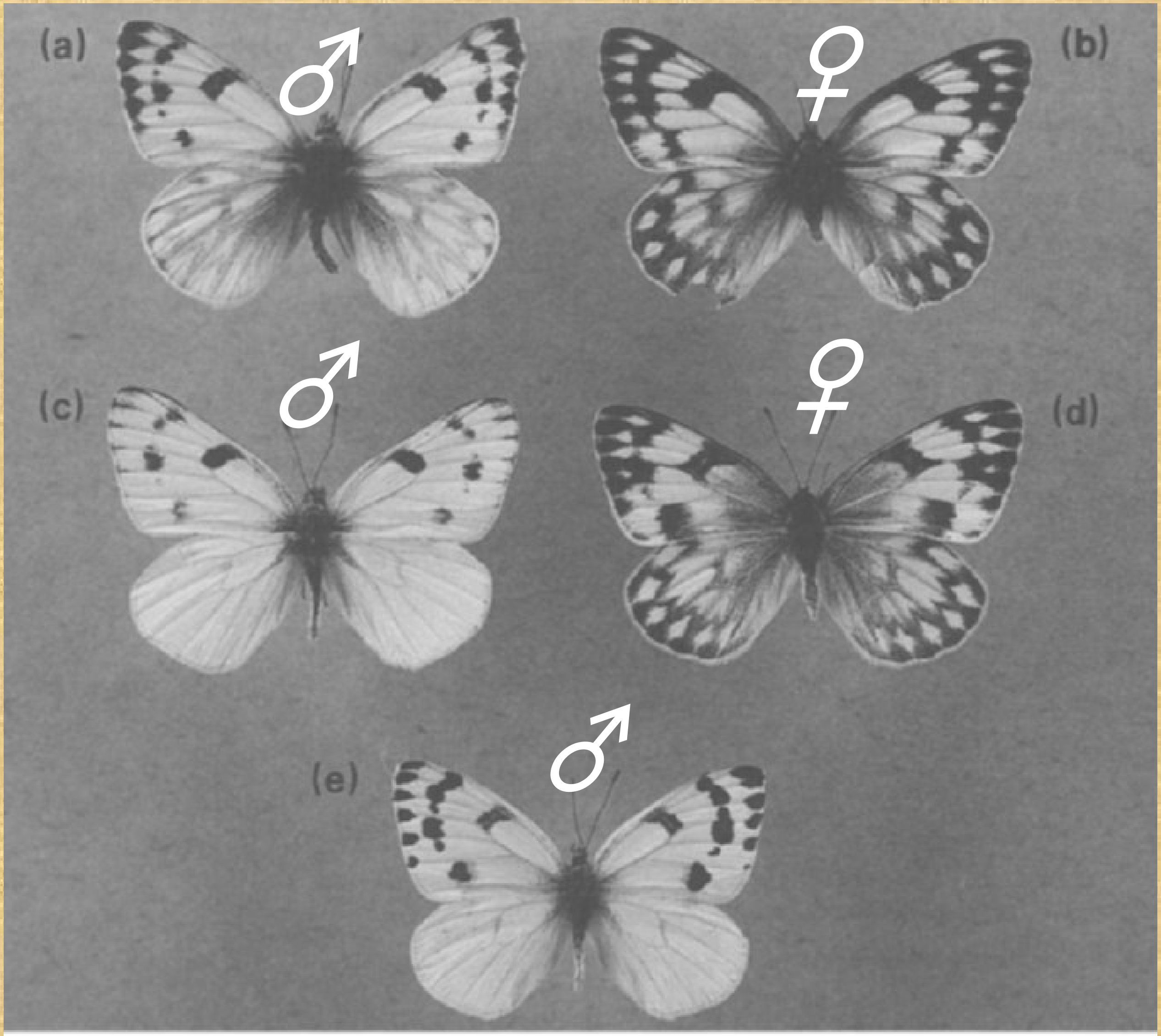
Arnqvist et al., 2000

Group 2

P. occidentalis

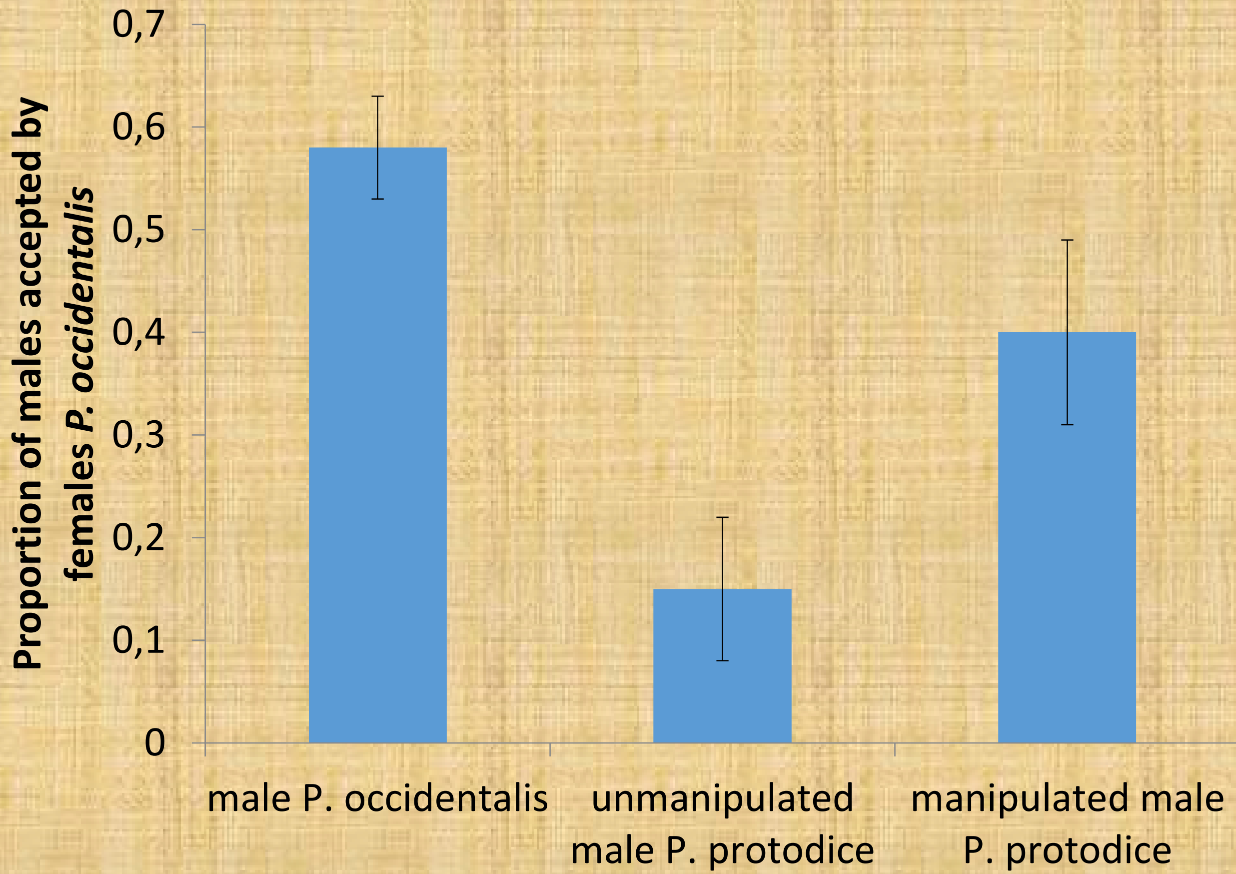
P. protodice

Manipulated P. protodice



Wiernasz and Kingsolver, 1992

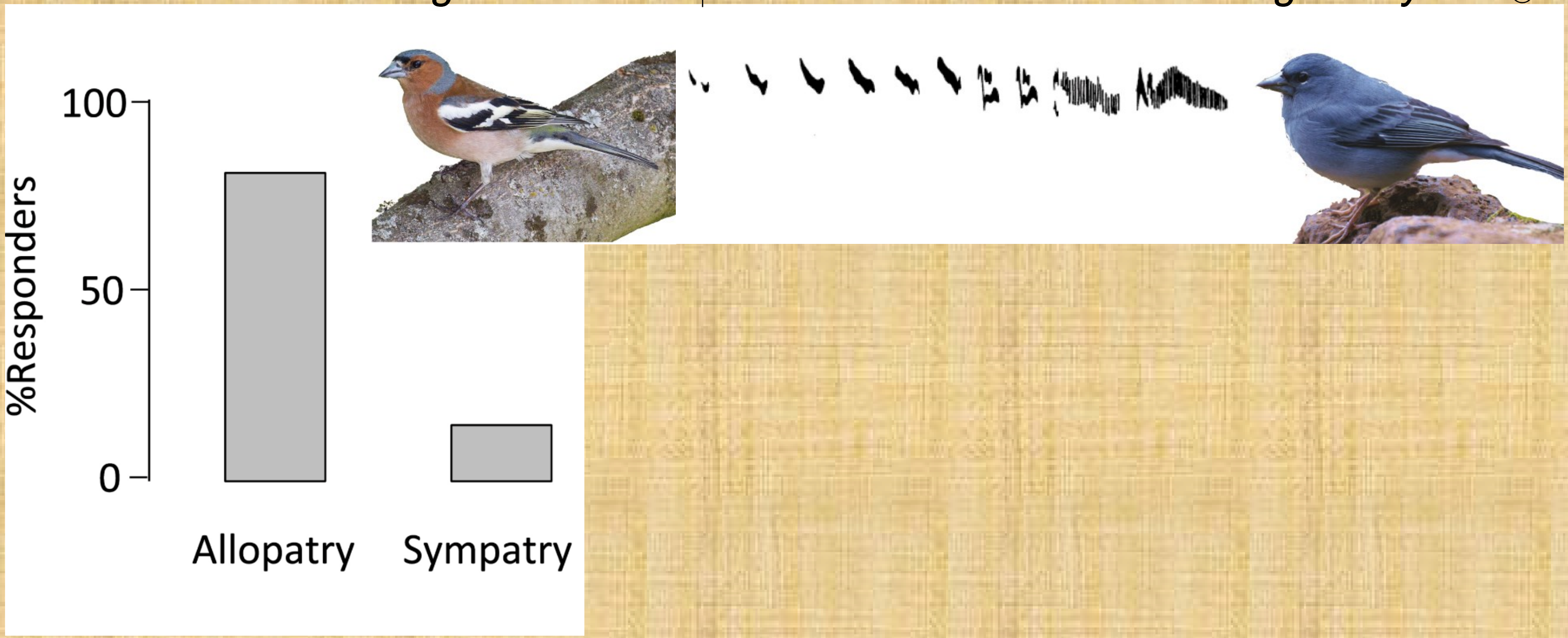
Speciation caused by colour choice by female



Wiernasz and Kingsolver, 1992

Reinforcement – learning to recognize own species by voice

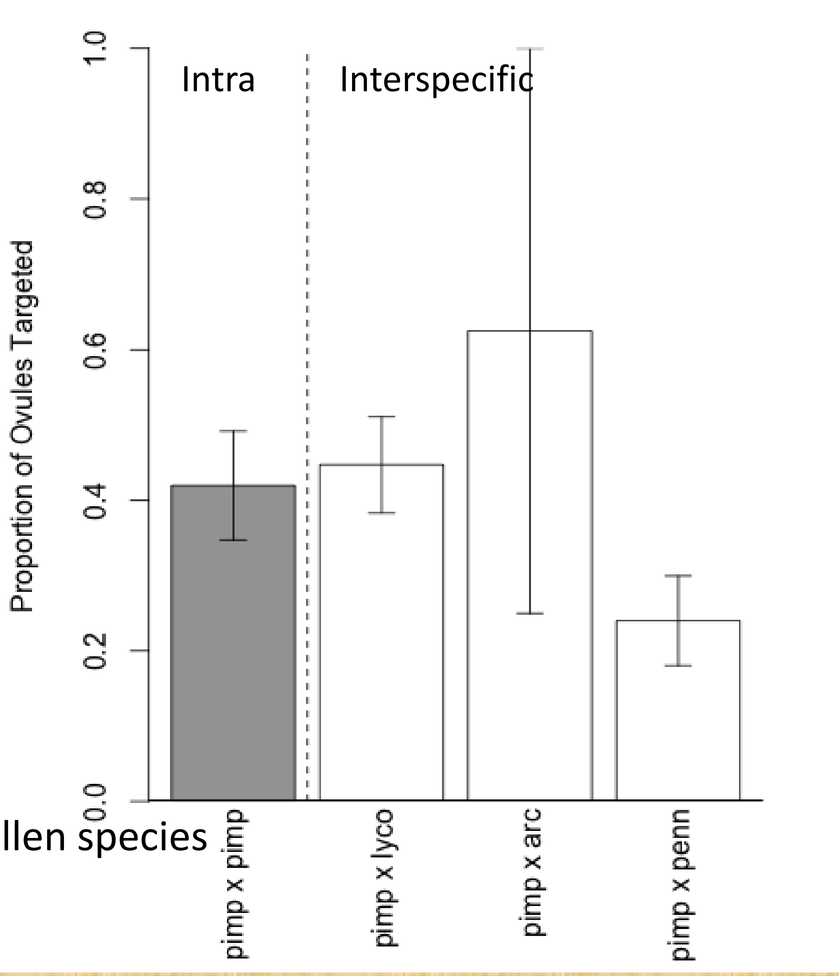
Fringilla coelebs ♀ *Fringilla teydea* ♂



Hudson and Price, 2014

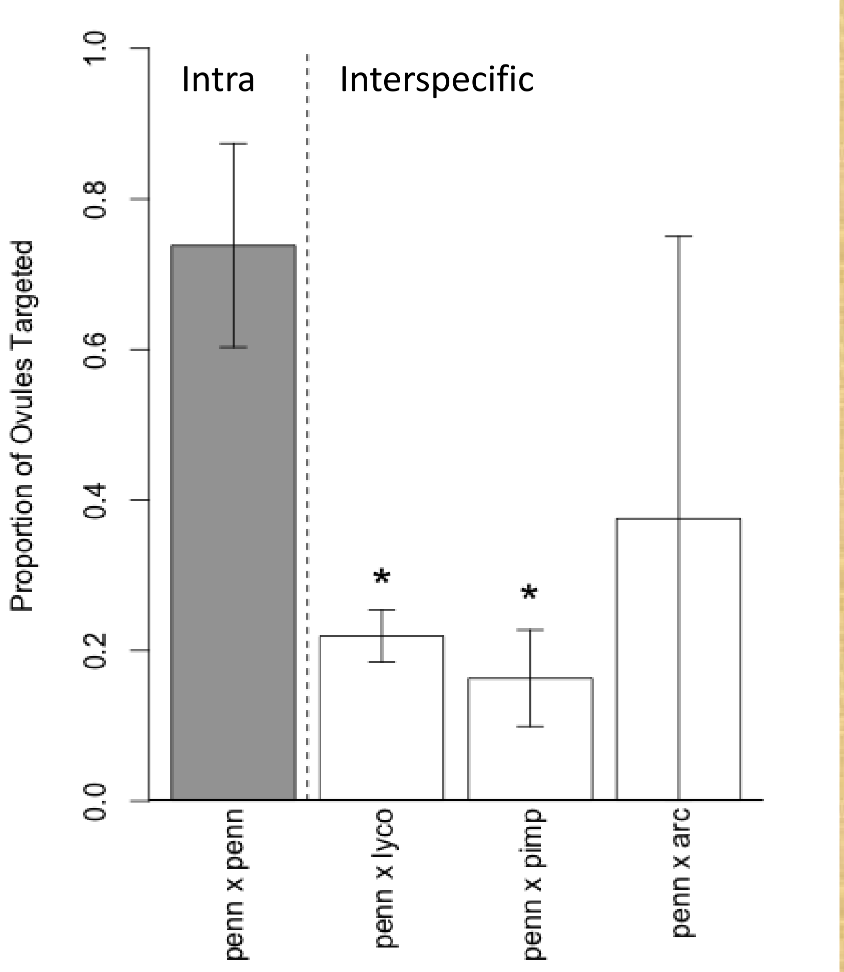
Group 3

The level of intraspecific influences the intensity of interspecific pollen selection



Pollen species

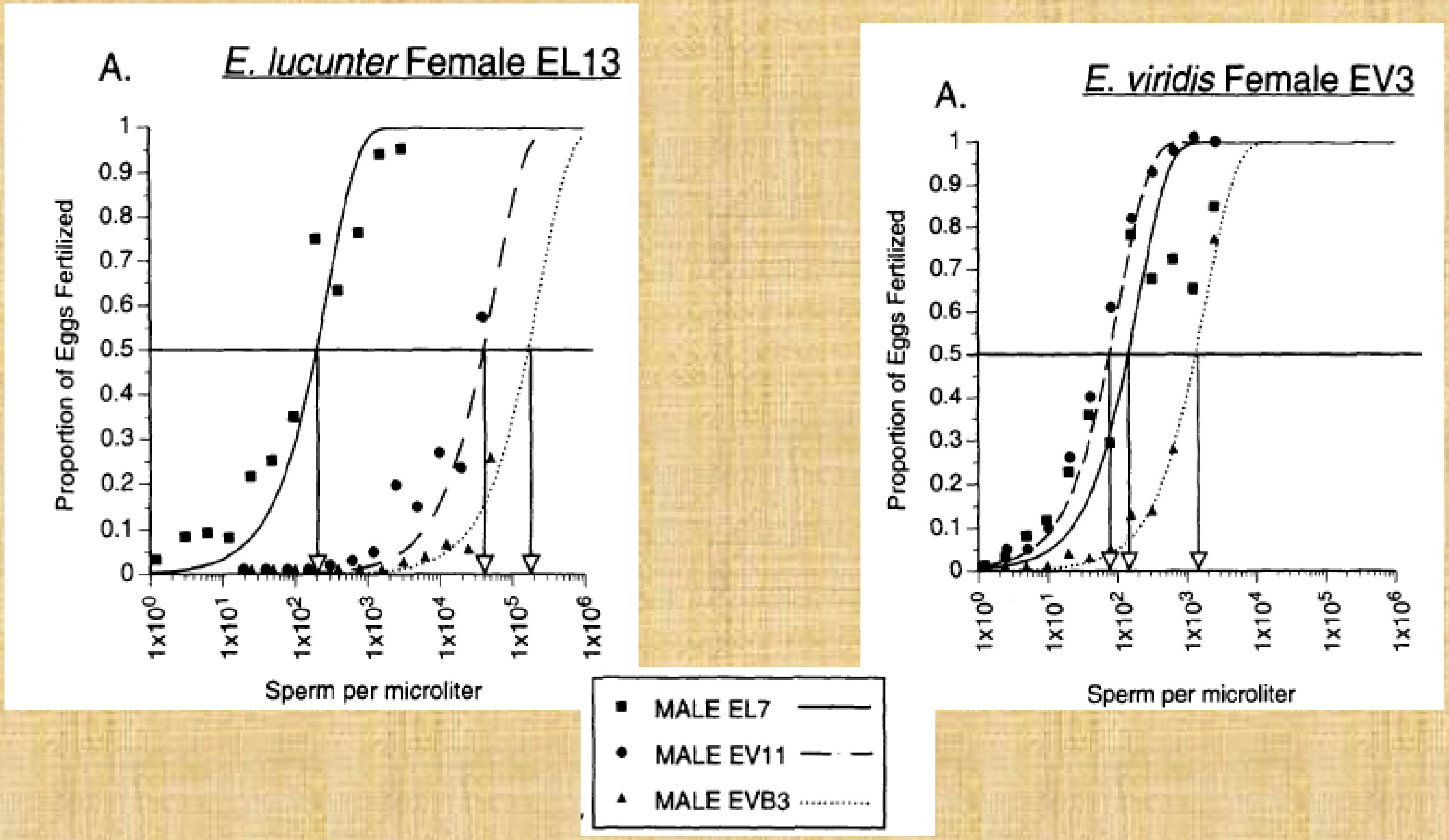
S. pimpinellifolium (self-compatible) ovules



S. pennellii (self-incompatible) ovules

Moyle et al., unpublished

Gametic isolation can be asymmetric

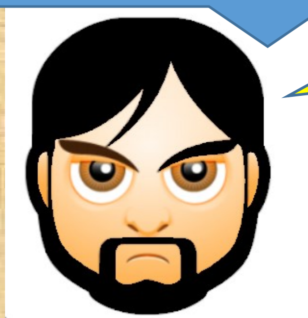


McCartney and Lessios, 2002

The parental conflict theory

Genomic “message” to the developing progeny:

“Grow big and strong, use all maternal resources.”

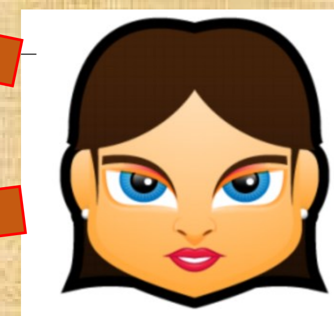


Positive selection

♂

Genomic “message” to the developing progeny:

“Grow well, but leave some resources for the other progenies.”



♀

Positive selection

Evolution towards a “selfish”/ “demanding” influence

Conflict of interests

Evolution towards a “repressive”/ “equitable” influence

How parent conflict can lead to postzygotic barriers

“Promiscuous” species

Siblings from different males

↓

Pressure for “selfish” males

↓

Pressure for “repressive” females

↓

High level parental conflict

↓

“Strong” parent

“Monogamous” species

Siblings from mainly one male

↓

Same paternal and maternal interests

↓

Low level parental conflict

↓

“Weak” parent

Abnormal growth of placenta in the mouse interspecific hybrids

The promiscuo … amous one

Brandvain et Haig, 2005

The genomics of SS/SC-mediated sexual isolation?

A certain trait is involved in intrasexual competition/mate selection/reproductive success/reprod. success + deleterious to the other sex (SC)

The same trait is responsible for sexual isolation between related species

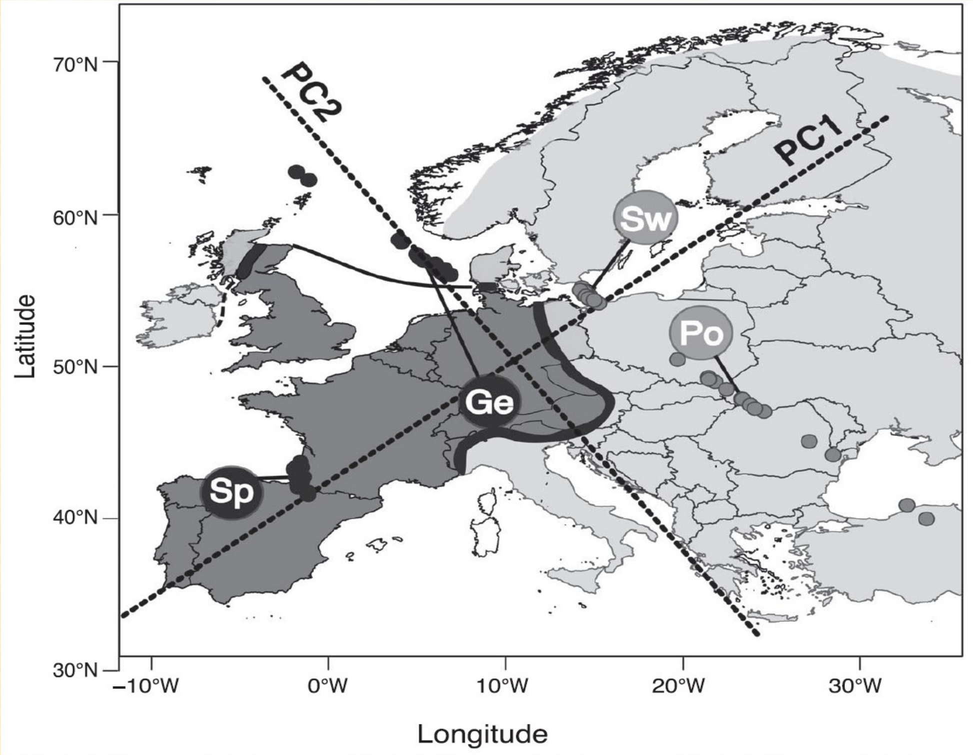
The underlying loci should:

- be divergent between species (species-specific alleles?)
- under selection
- be functionally tested for their role in SS/SC and reproductive isolation between species

What allows genetic/phenotypic distinctiveness?

Corvus cornix

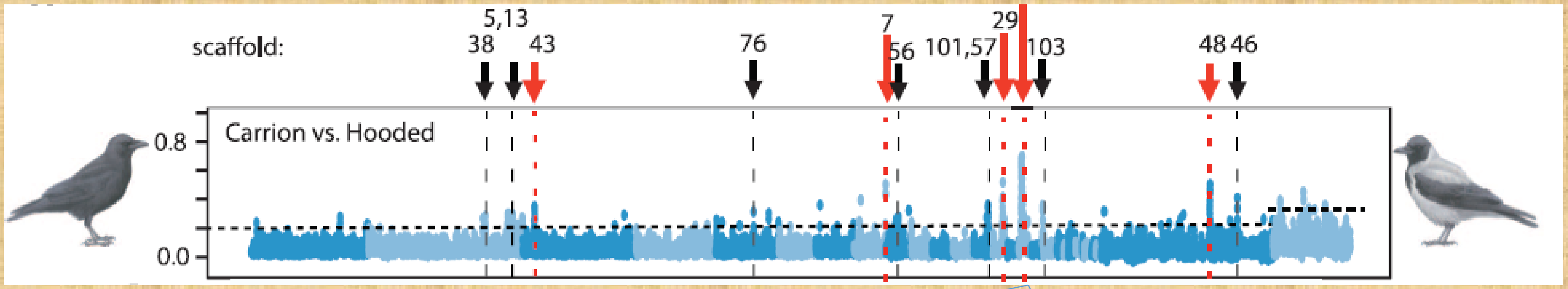
Corvus corone

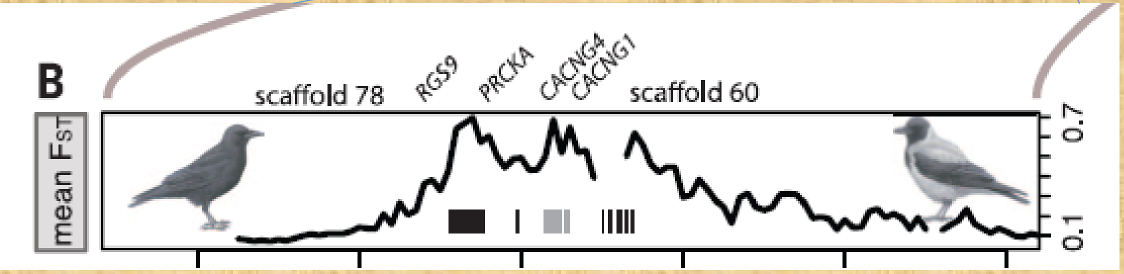


Poelstra, 2014

What allows genetic/phenotypic distinctiveness?

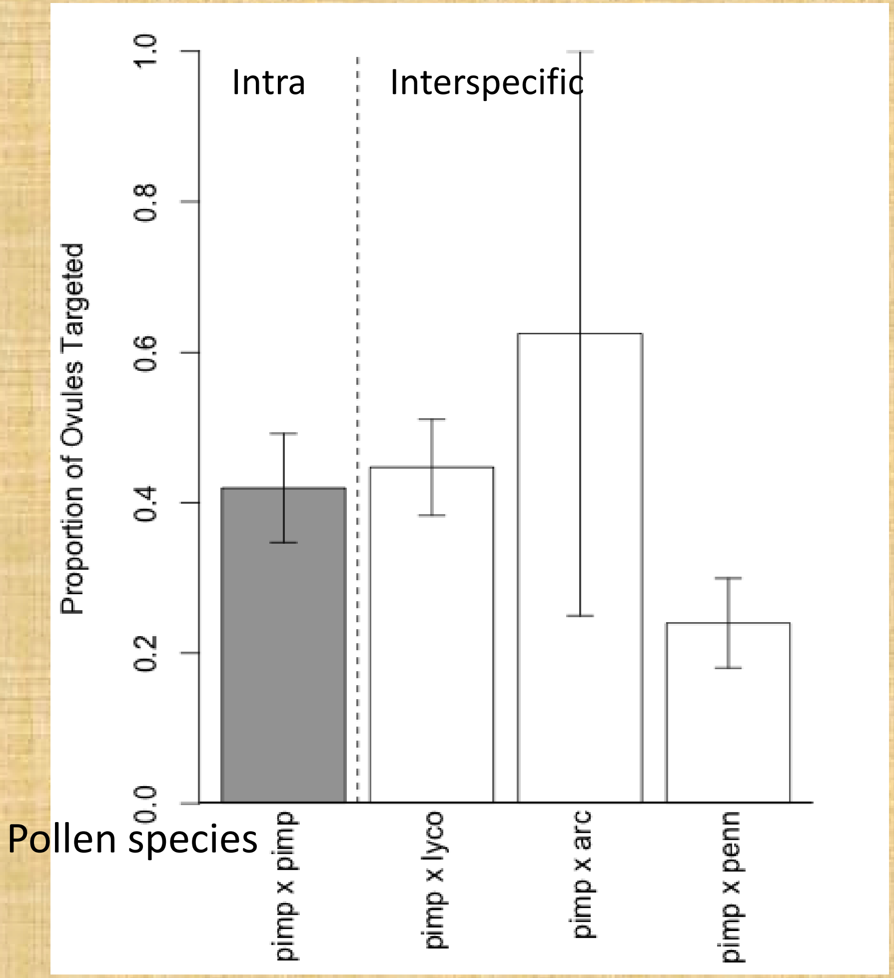
Differentiation (F*st*)





Genes involved in **melanogenesis** AND **visual perception**

Poelstra, 2014



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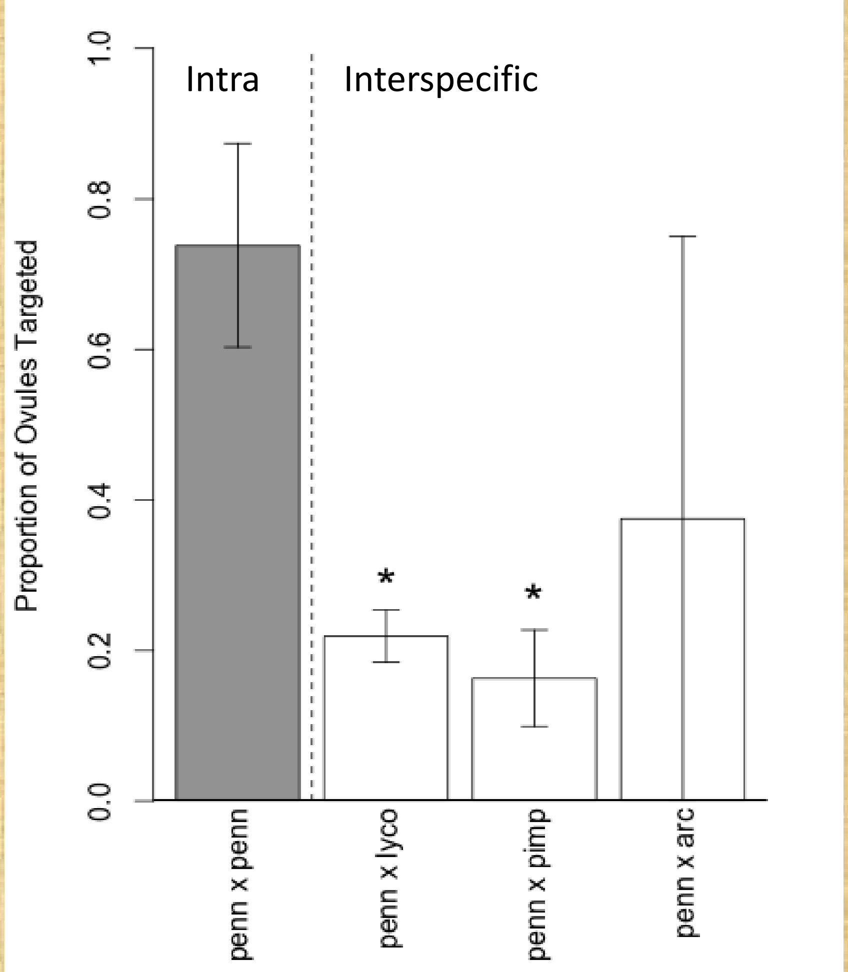
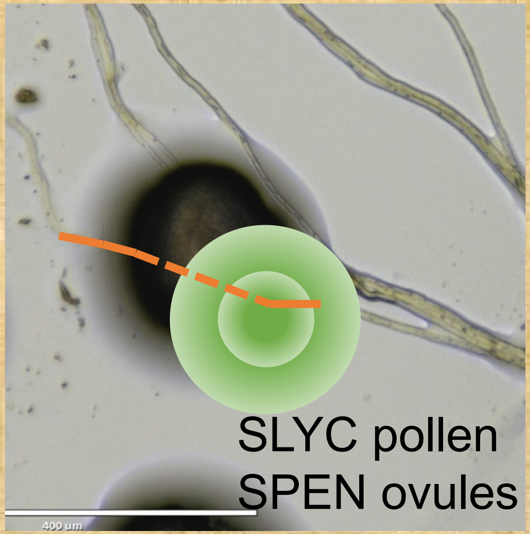


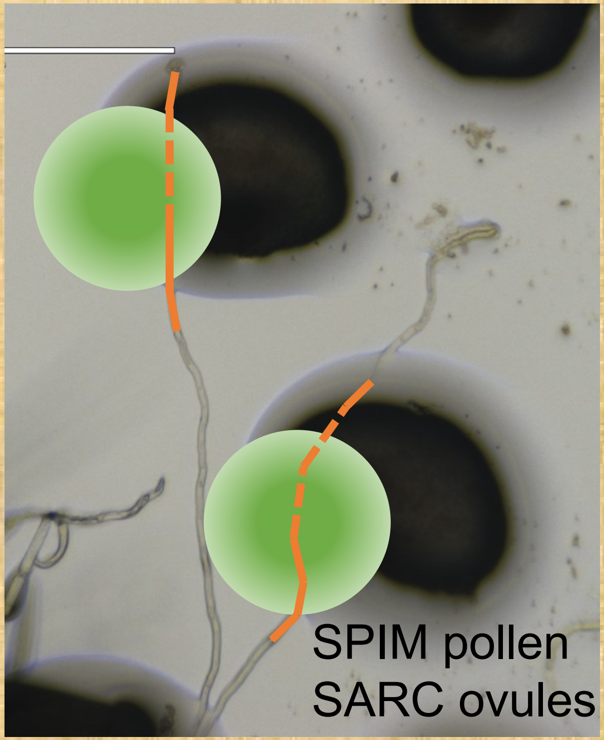
S. pennellii (self-incompatible) ovules

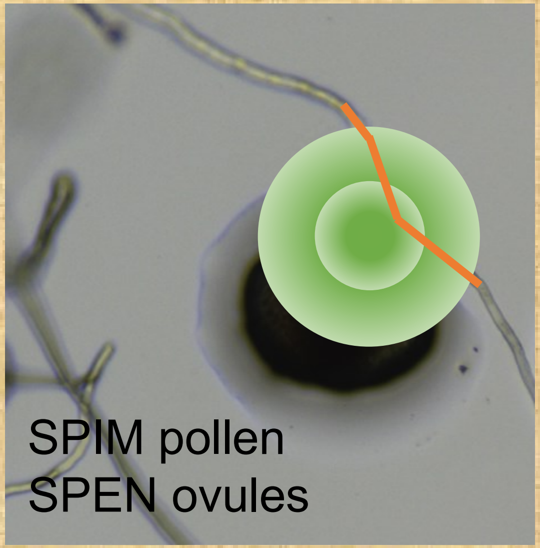
Moyle et al., unpublished

Results

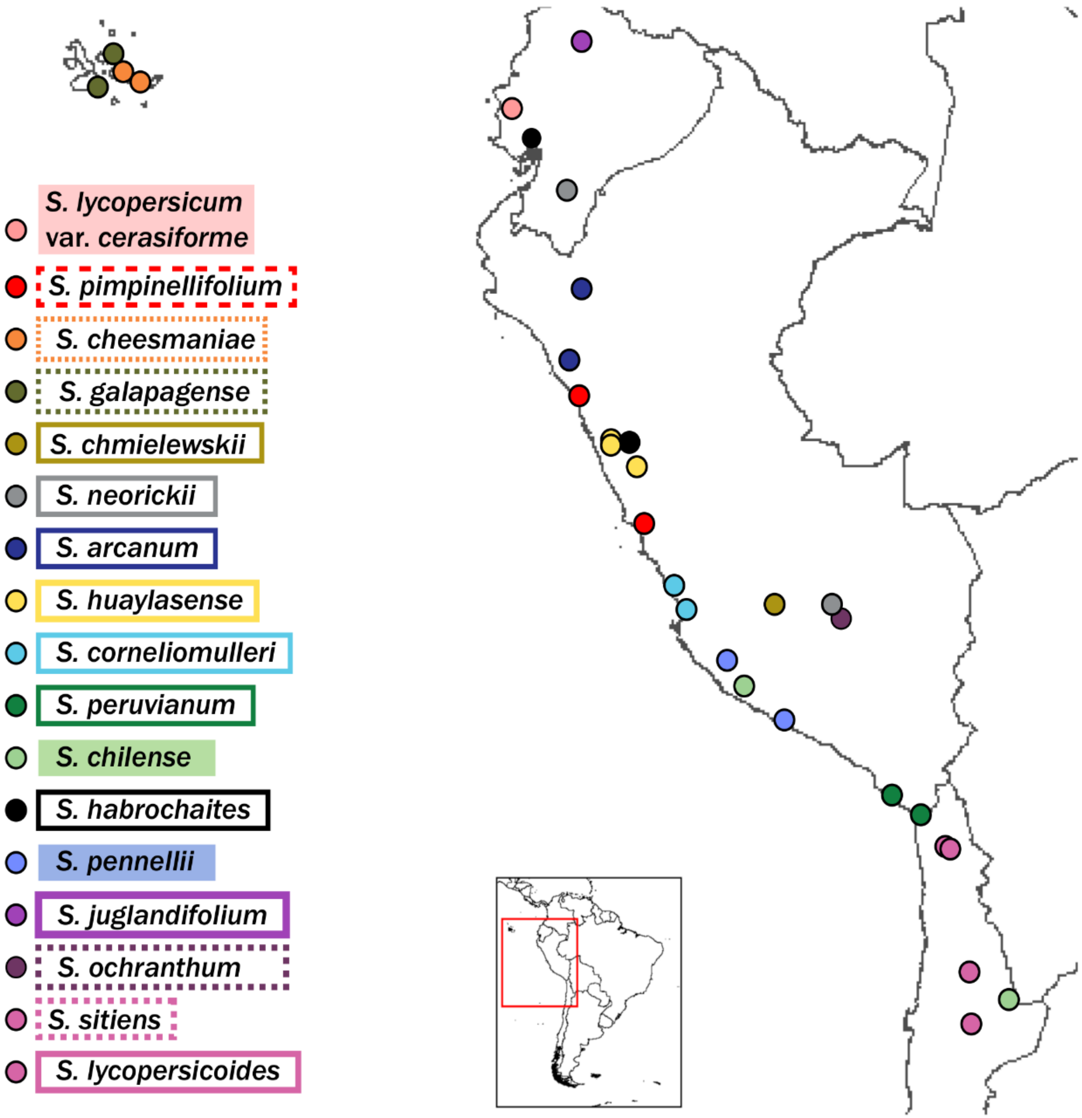
Gamete isolation between species







Chemoattraction by ovules: female cryptic choice?



RNAseq in *Solanum*

Whole (multi-tissue) transcriptome sequencing in 36 accessions (2+ of every species)

<u>To date</u>: assembled av. ~26,200 loci (transcripts) in each of 29 accessions

~ 76% of all known tomato coding regions

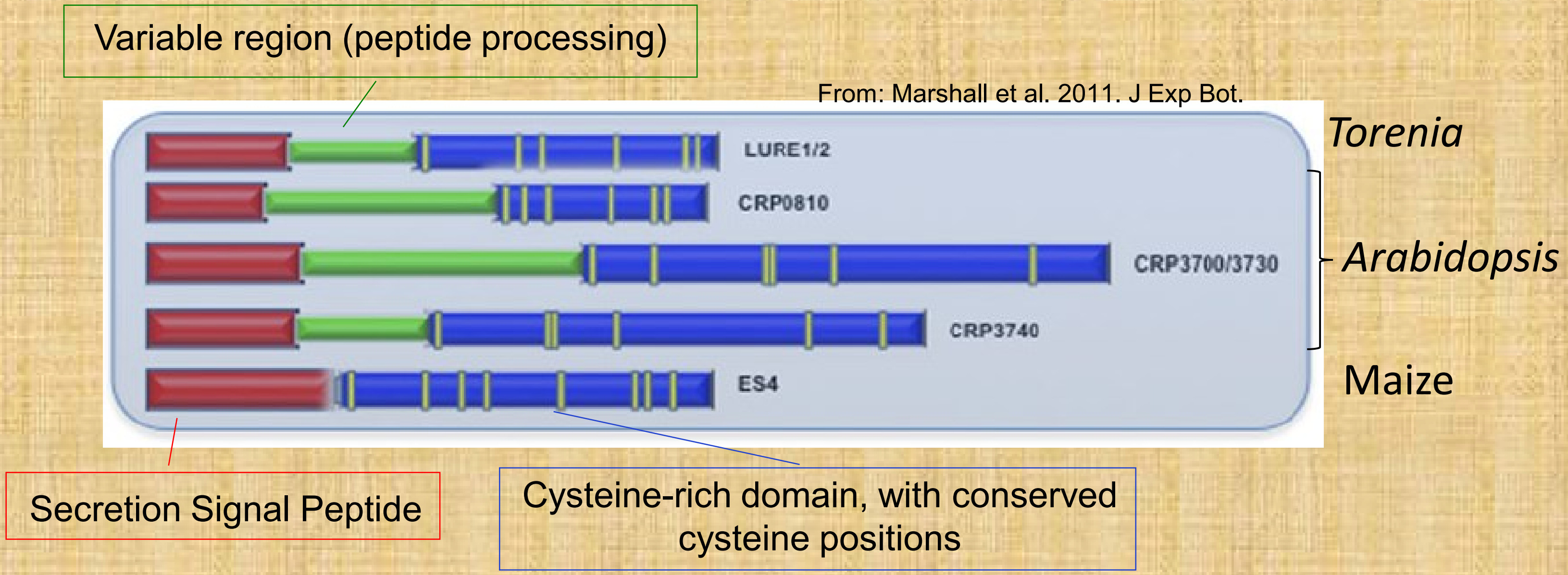
Matthew Hahn

James Pease

Molecular mechanism?

Candidate ovule-secreted chemoattractants:

1. cysteine-rich peptides (CRPs)

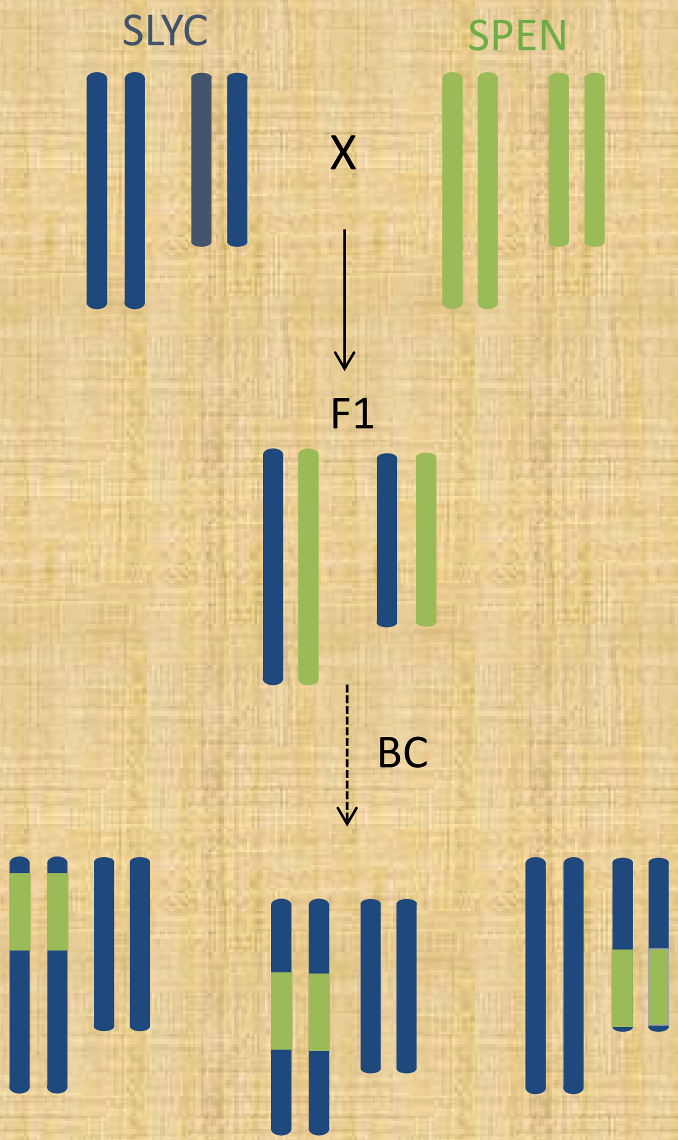


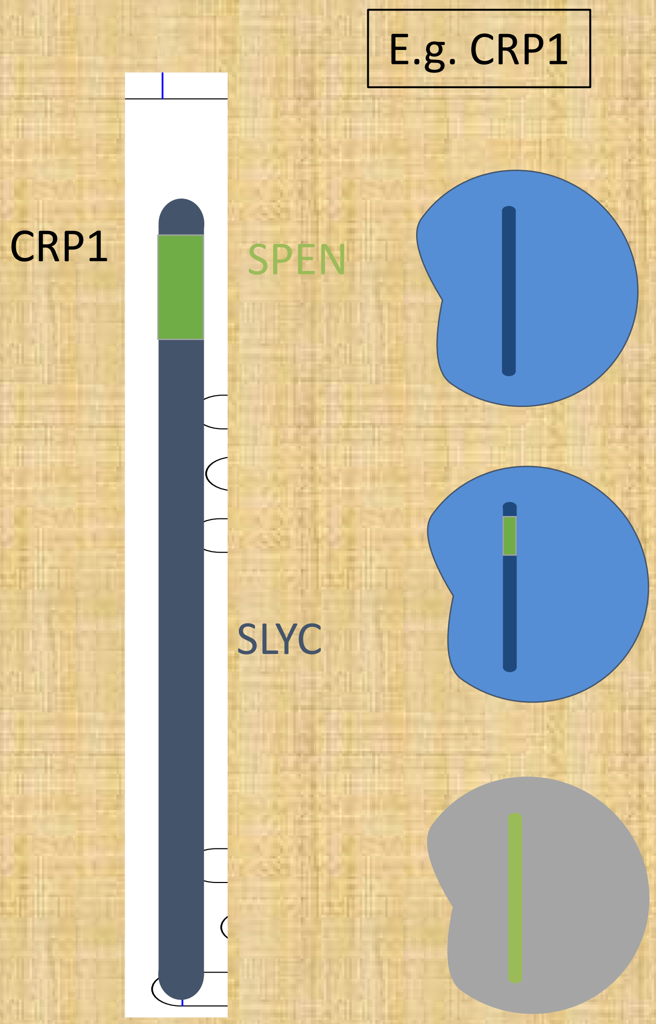
2. highly expressed in ovules

Candidate ovule chemoattractants in *Solanum*

	CRP1	**CRP2**
• Transcript abundance in ovules	Very high	Very high
• Structurally CRP	Yes	Yes
• Potential functional (aa) changes?	Yes	Yes

Testing candidate ovule chemoattractants using introgression lines





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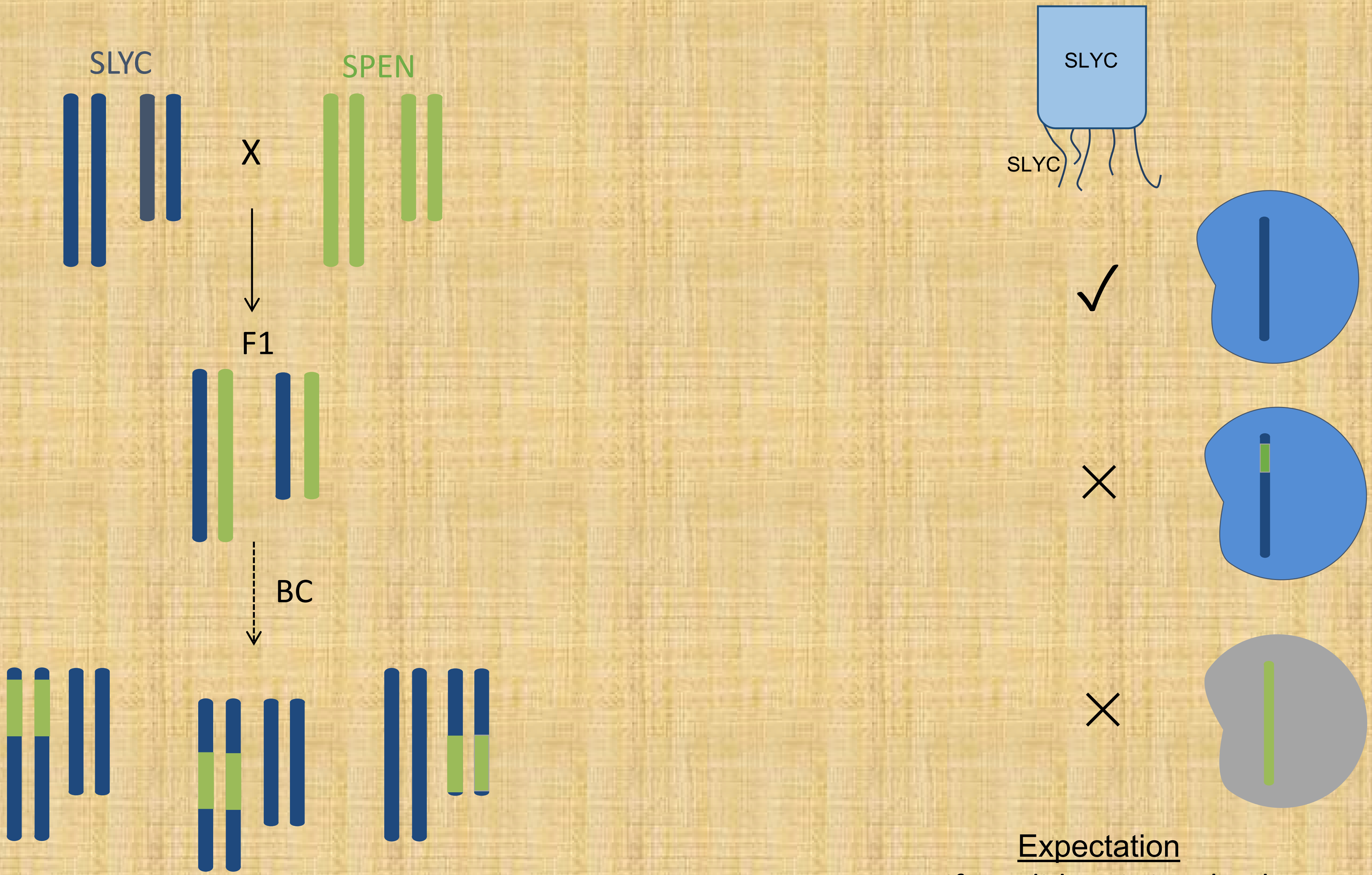
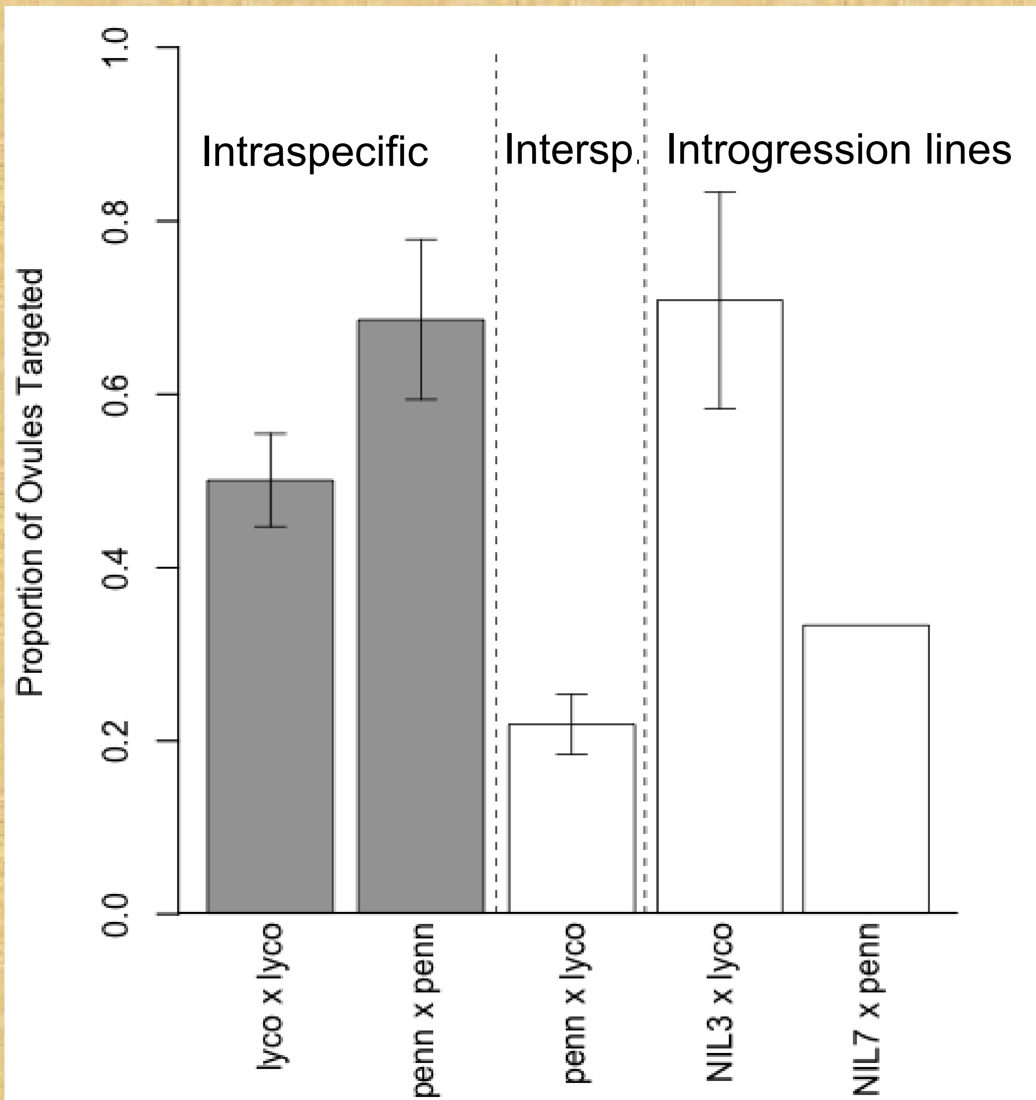
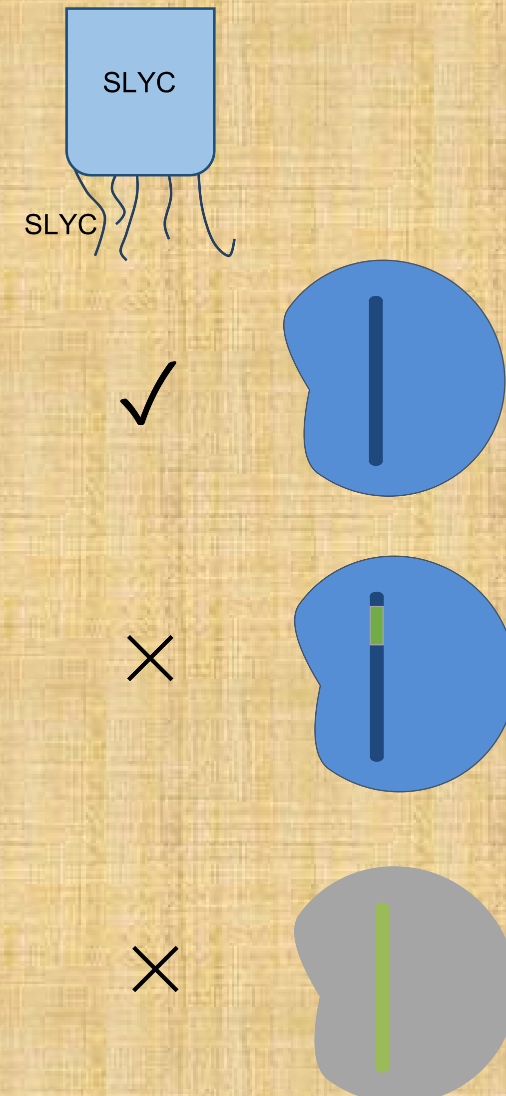


<u>Expectation</u>
if candidate is involved

Testing candidate ovule chemoattractants using introgression lines

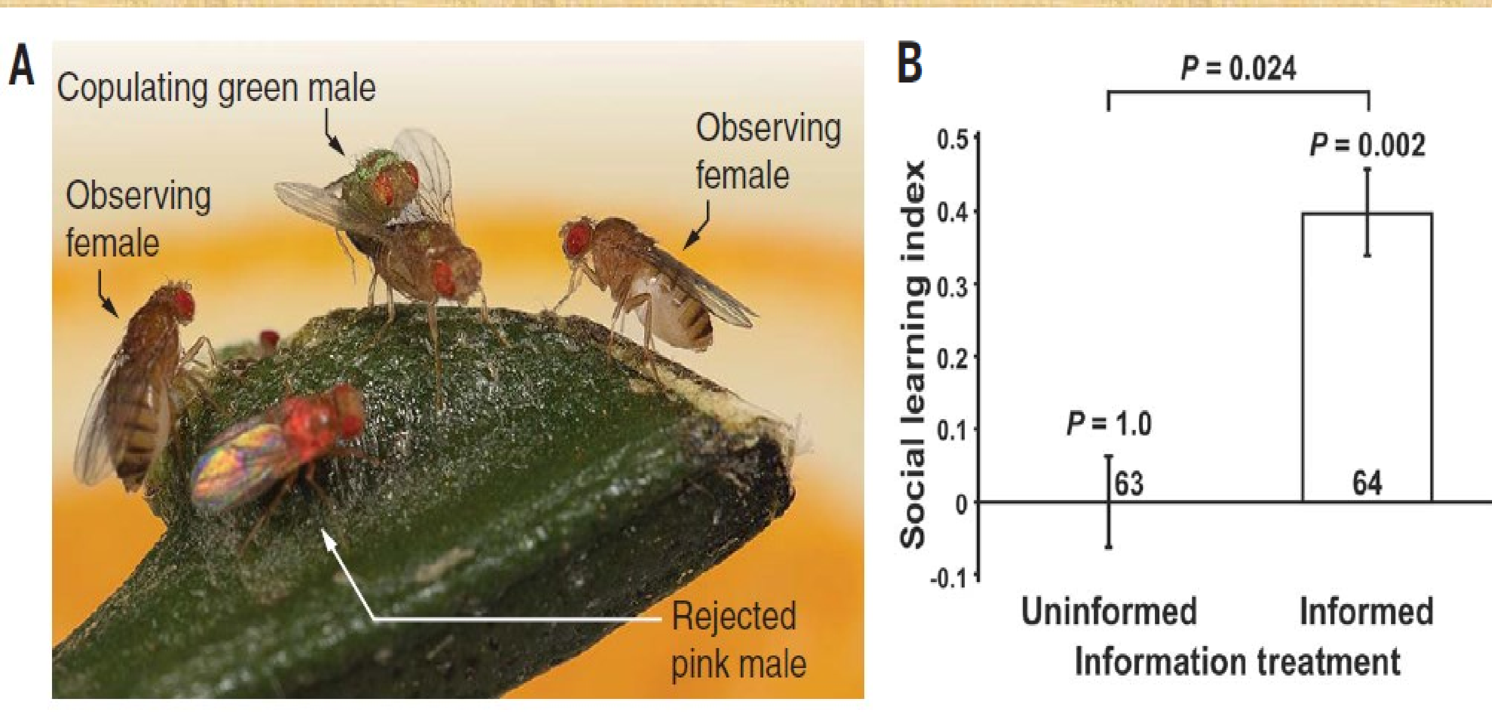


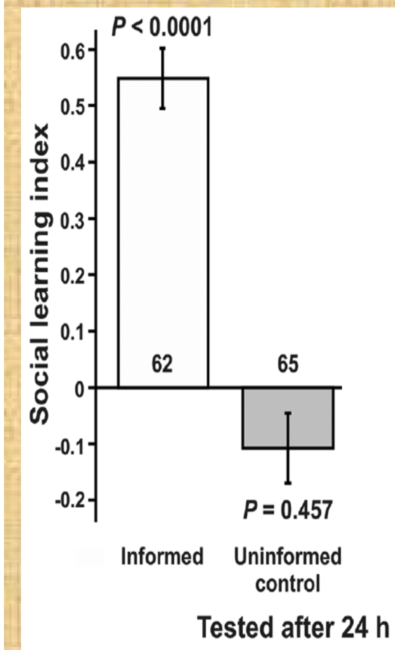
Observed CRP1 CRP2



Expectation
if candidate is involved

The cause of sexual isolation is not always genetic





Cultural shift in partner preference can cause speciation by behavioral isolation

Danchin et al., 2018

Conclusions

Sexual genes evolve faster than other genes, partly due to sexual selection/conflict

Sexual selection can lead to (fast) pre- and post-mating isolation

Sexual (behavioral, gametic…) divergence does not necessarily mean isolation

Genomics of sexual selection-driven speciation is still nascent

Sexual isolation may not have any genetic basis