The co-evolving genome

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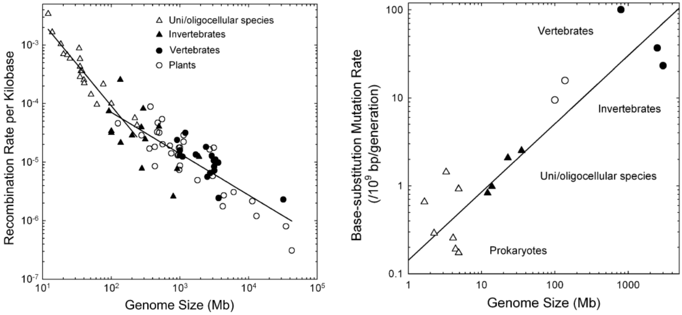
The genome as a fixed trait

A simplifying hypothesis in evolutionary/inference models is a non-changing genome.

Are we missing key evolutionary dynamics by making this assumption?

Distribution of genome sizes

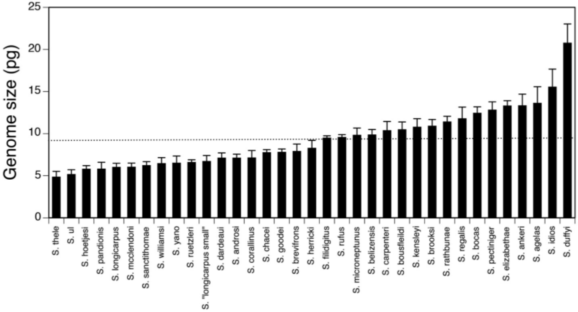
Correlation with other processes

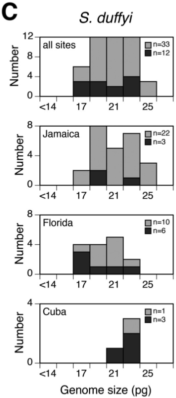


(From Lynch 2006)

Distribution of genome sizes

Across and within species





Snapping shrimp (From Jeffery e al. 2016)

How does GS evolve?

Two schools of thought:

(nearly) Neutral theory

- GS increases due to drift
- Decrease of GS:
  - Light selection (cost of replication) (Lynch 2010)
  - Small random deletions (Petrov 2002)

Selection as a main driving force

- GS reflects sensitivity to new mutations (Elena et al. 2007)
- GS as a maladaptive trait (reduces speed of cell division) (Cavalier-Smith 2005)

→ Larger effective population size (N_e) should favour smaller genomes

A link between GS and life-history?

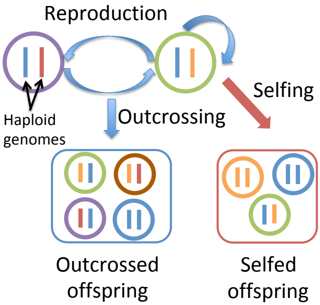
If larger effective population size (N_e) should favour smaller genomes....

1. Is there a link between genome size and life-history traits?
2. What role would selection play?

$\rightarrow$ The case of persisting self-fertilising species

Disclaimer: I will not/cannot answer either of these questions today.

Quick Introduction to Self-fertilisation



→ Potential to transmit a large number of different combinations of the parental haplotypes

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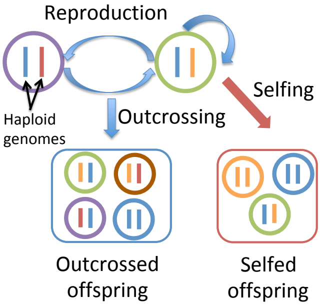
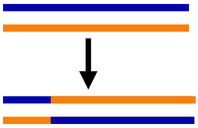
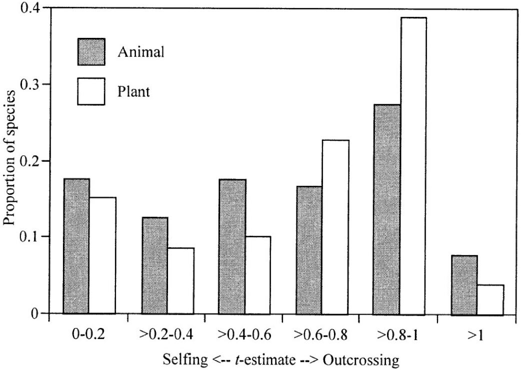


Not to be confused with a-sexuality!

Recombination makes a difference



→ Potential to transmit a large number of different combinations of the parental haplotypes

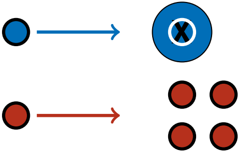


Jarne and Auld 2006

$\rightarrow \approx$ 15% of plant species predominantly self-fertilise
(Igic and Kohn 2006)

Advantages of self-fertilisation

Reproductive assurance



Advantages of self-fertilisation

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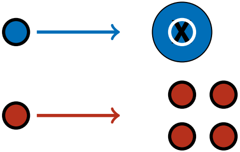

- Faster fixation of beneficial alleles
- Purge of deleterious mutations

Advantages of self-fertilisation

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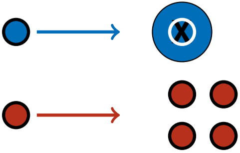

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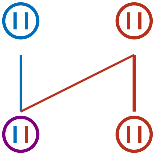
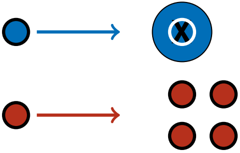
Automatic advantage



Fisher (1941)

Advantages of self-fertilisation

Reproductive assurance



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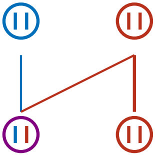


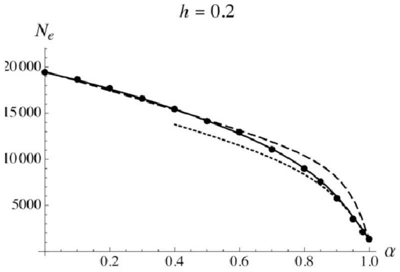
Fisher (1941)

$\rightarrow$ Unidirectional evolution to high selfing rates

(Lande and Schemske 1985)

Consequences of self-fertilisation

Reduced effective population size (N_e)

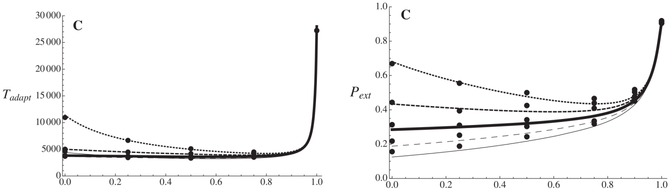


From: Roze (2015)

- Lower genetic diversity (Lower adaptive potential)
- Fixation of mildly deleterious mutations (mutational meltdown)

→ Higher extinction rates?

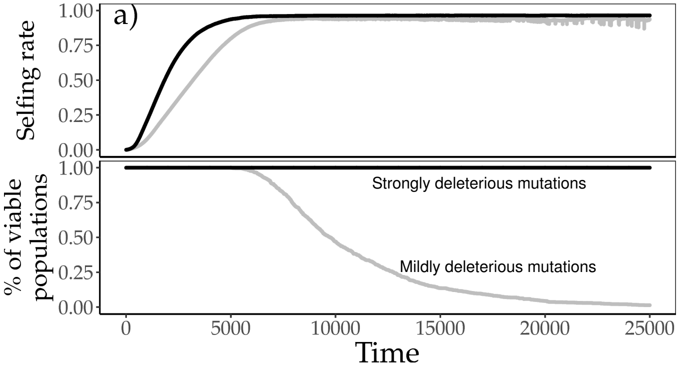
Adaptive potential



Selfing rate

From: Glémin and Ronfort (2013)

Mutational meltdown

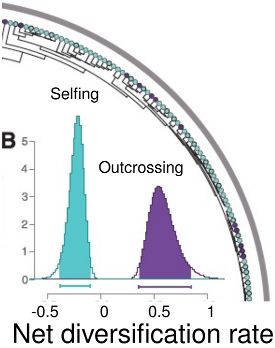


From: Abu Awad and Billiard (2017)

An evolutionary dead-end?

(Takebayashi and Morrell 2001, Igic and Bush 2013)

Loss of Self-Incompatibility and extinction:



From: Goldberg et al. (2010)

- Unidirectional evolution from outcrossing to selfing

And:

- Failure to adapt
- Mutational meltdown

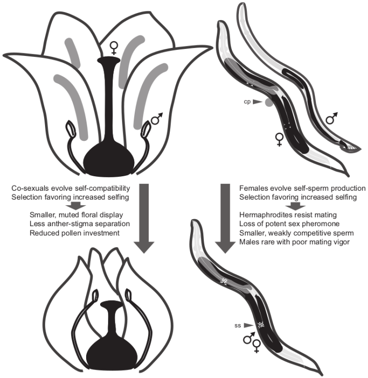
But these processes are too fast to be observed on a phylogenetic scale.

(*i.e.* A. thaliana and A. lyrata diverged 5 mya ...)

The selfing syndrome

The transition from outcrossing to selfing is correlated with:

- Changes in reproductive investment
- Shift to an annual from a perennial life-history (plants)
- Decrease in genome size



(From Cutter 2019)

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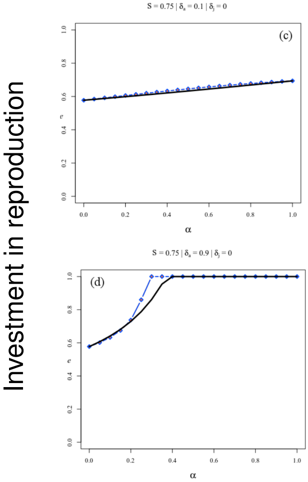

(From Lesaffre and Billiard 2010)

The selfing syndrome

The transition from outcrossing to selfing is correlated with:

- Changes in reproductive investment
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- Decrease in genome size

$\rightarrow$ GS as maladaptive

(speed of replication)

The selfing syndrome

The transition from outcrossing to selfing is correlated with:

- Changes in reproductive investment
- Shift to an annual from a perennial life-history (plants)
- **Decrease in genome size**

$\rightarrow$ Against expectations for GS evolution! (small $N_e \rightarrow$ large GS)

How should GS evolve in selfers?

Small effective population size...

(nearly) Neutral theory

- GS increases due to drift
- Decrease of GS:
  - Light selection (cost of replication) (Lynch and Conery 2003)
  - Small random deletions (Petrov 2002)

Selection as a main driving force

- GS defines sensitivity to new mutations (Elena et al. 2007)
- GS as a maladaptive trait (reduces speed of cell division) (Cavalier-Smith 2005)

Inconclusive.

What makes up the genome?

Simply put:

(non-exhaustive)

- Functional and non-functional genes (duplications..)
- Non-coding DNA (ncDNA)
- Transposable Elements

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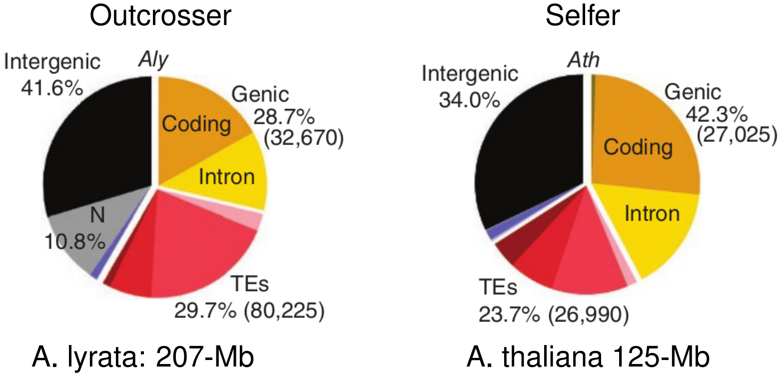
$\rightarrow$ **What is lost in selfers?**

What makes up the genome?

After a shift from outcrossing to selfing



From Hu et al. 2011

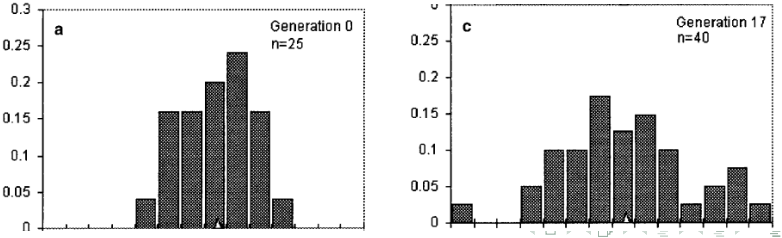
Hundreds of thousands of small deletions → selection is ongoing

Beyond genome size...

Selfing is predicted to:

- increase the recombination rate (Roze and Lenormand 2006)
- either increase or decrease the mutation rate depending on the N_e (Gervais and Roze 2017)
- There may be an effect on robustness (Shaw et al. 2000)

Number of seeds as a measure of fitness in mutation accumulation lines:



The co-evolving genome?

Could long-term persistence of selfing populations be a consequence of genome evolution?