On the origins of XY and ZW sex determination as an outcome of sex allocation evolution

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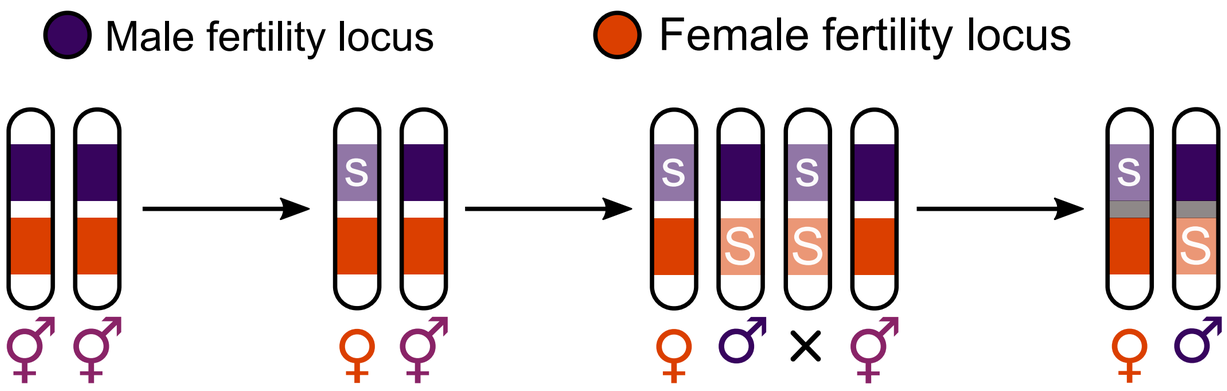
Background

The transition ♂ → ♀♂ is frequent in plants.

In ♀♂ plants, sex is typically determined by a single biallelic locus (XY/ZW systems).

Thus, transitions ♂ → ♀♂ likely often entailed the emergence of such a locus.

Classical "two-gene" model:

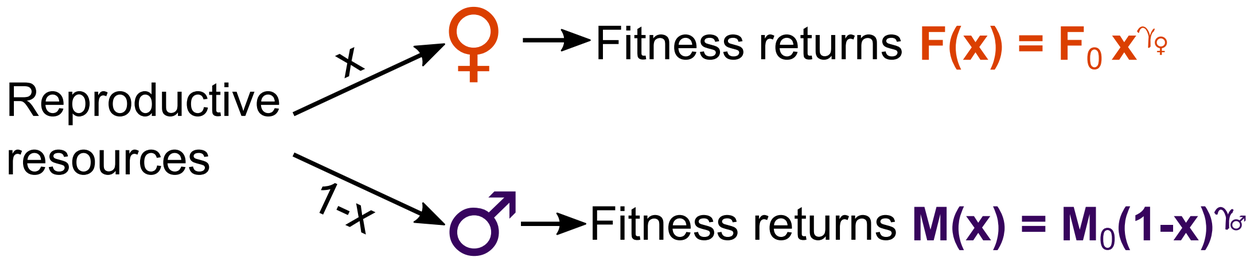


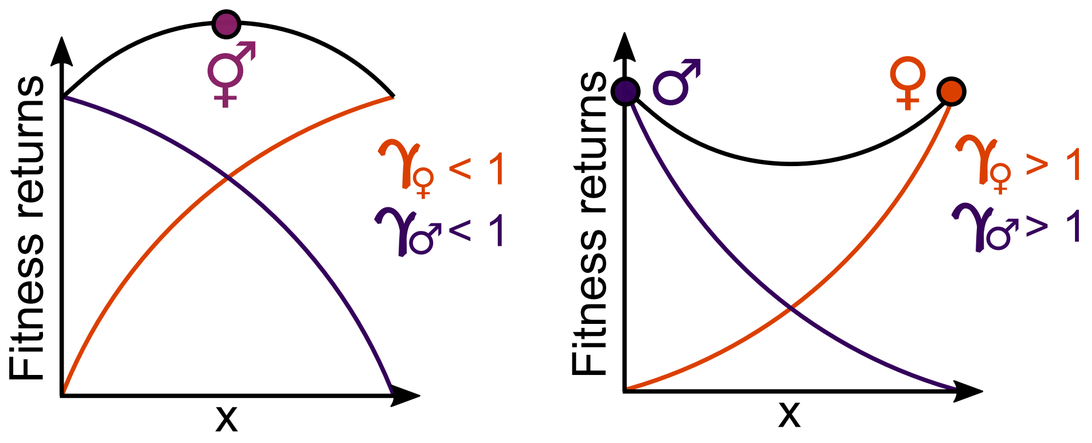
Assumes dominance is fixed and requires sterility mutations at closely linked genes.

Ignores the possibility of that dominance itself may evolve at sex-determining loci.

Sex allocation theory

Evolution of sexual systems can be viewed as a resource allocation problem.



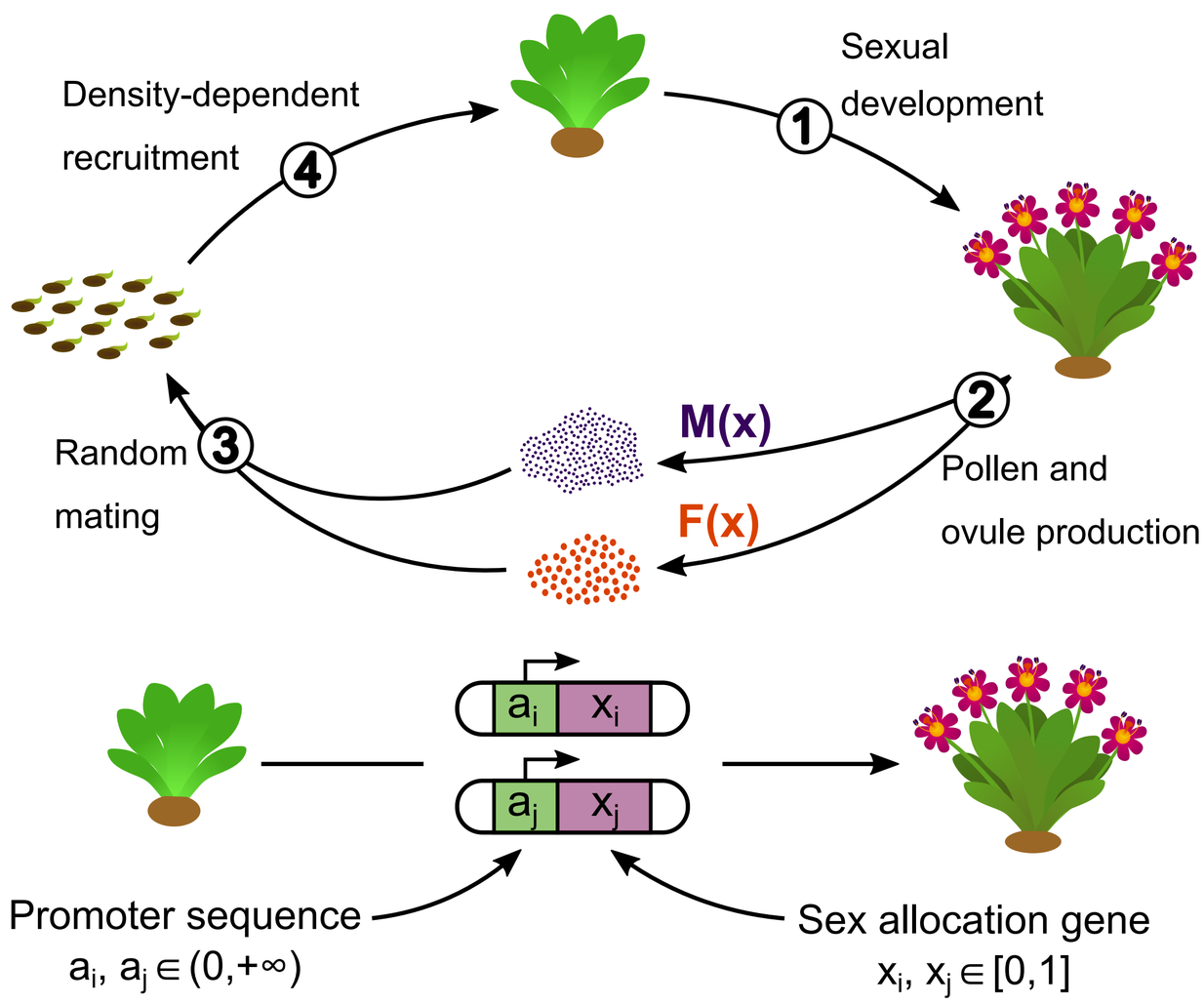


Diminishing returns maintain ♂, whereas increasing returns favour ♀♂.

Sex allocation theory explains transitions at a phenotypic level, but largely ignores the genetic basis of sex.

Here, we let sex allocation co-evolve with its underlying genetic architecture in diploids, and show that this co-evolution readily leads to the emergence of XY and ZW sex determination.

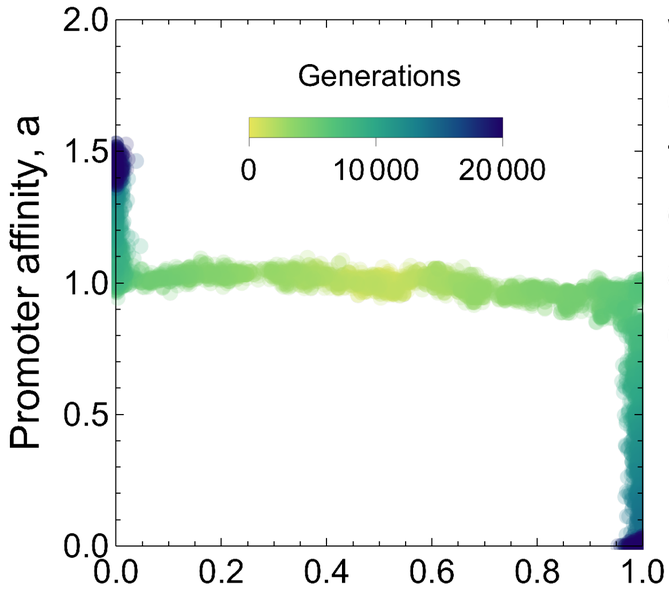
Model & results



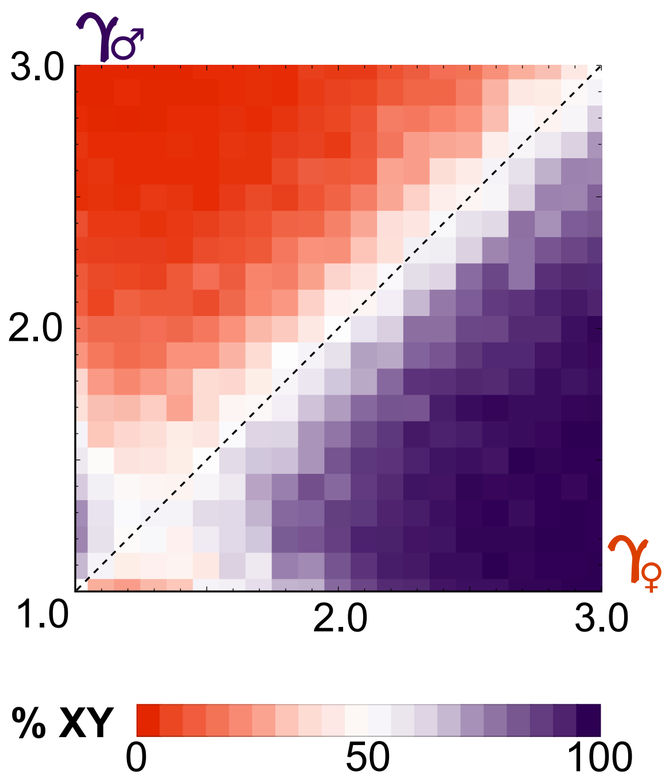
Promoter affinity (a) encodes dominance at the sex allocation gene.

$$x = x_i \frac{a_i}{a_i+a_j} + x_j \frac{a_j}{a_i+a_j}$$

Gradual emergence of XY/ZW systems



When $\gamma_♀ > 1$ and $\gamma_♂ > 1$, *disruptive selection* leads to the gradual differentiation of ♀ and ♂ alleles and the *evolution of dominance.*



The shape of fitness returns F(x) and **M(x)** determines whether an XY or a ZW system emerges through *(i)* its direct effect on the competitive edge of homozygotes over heterozygotes, and *(ii)* its indirect effect on the frequency of homozygotes for the female and male alleles. The combination of these two effects determines where the highest fitness gain is from the point-of-view of heterozygotes.

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