

# Self-fertilisation can be an evolutionary dead-end

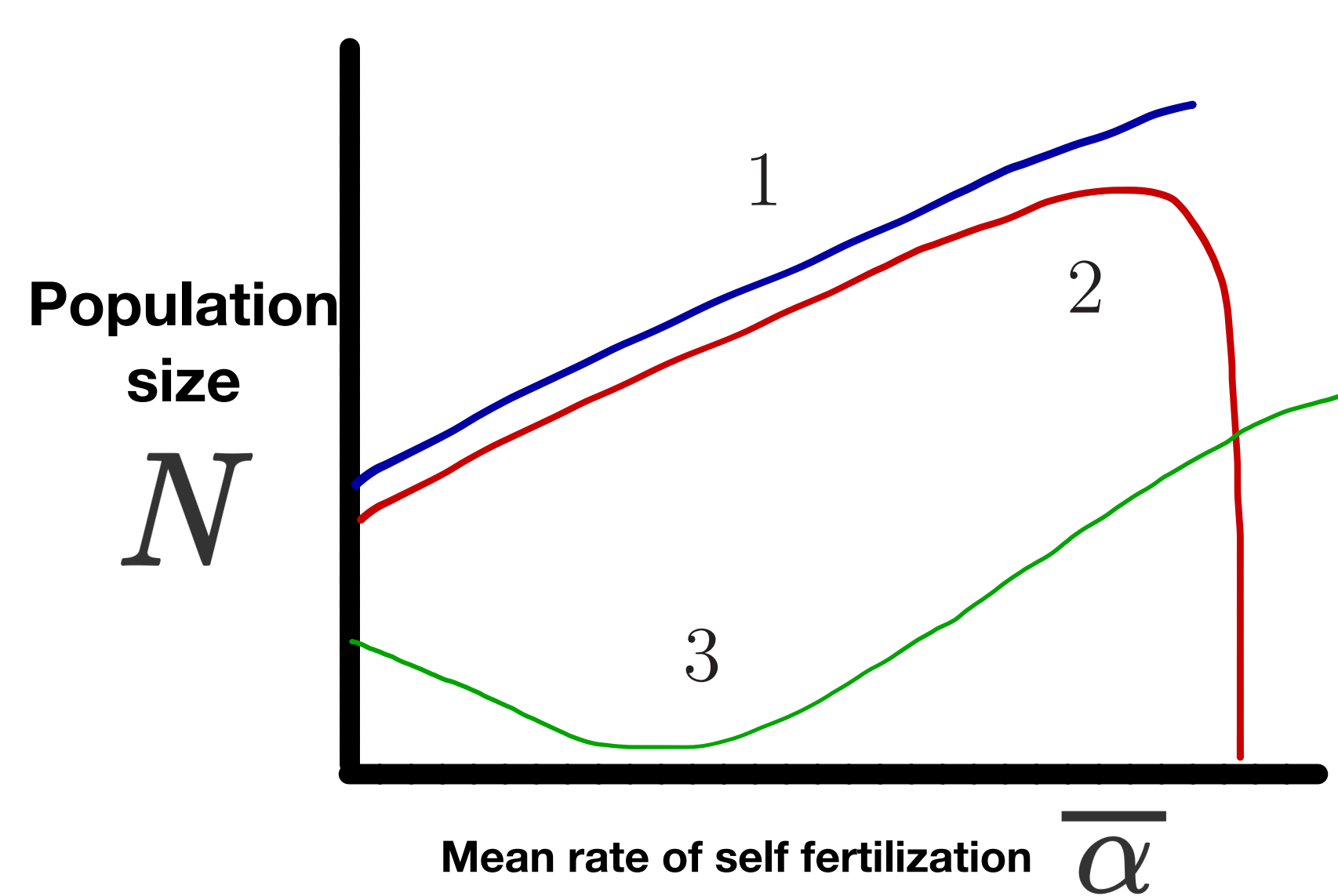
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## Introduction

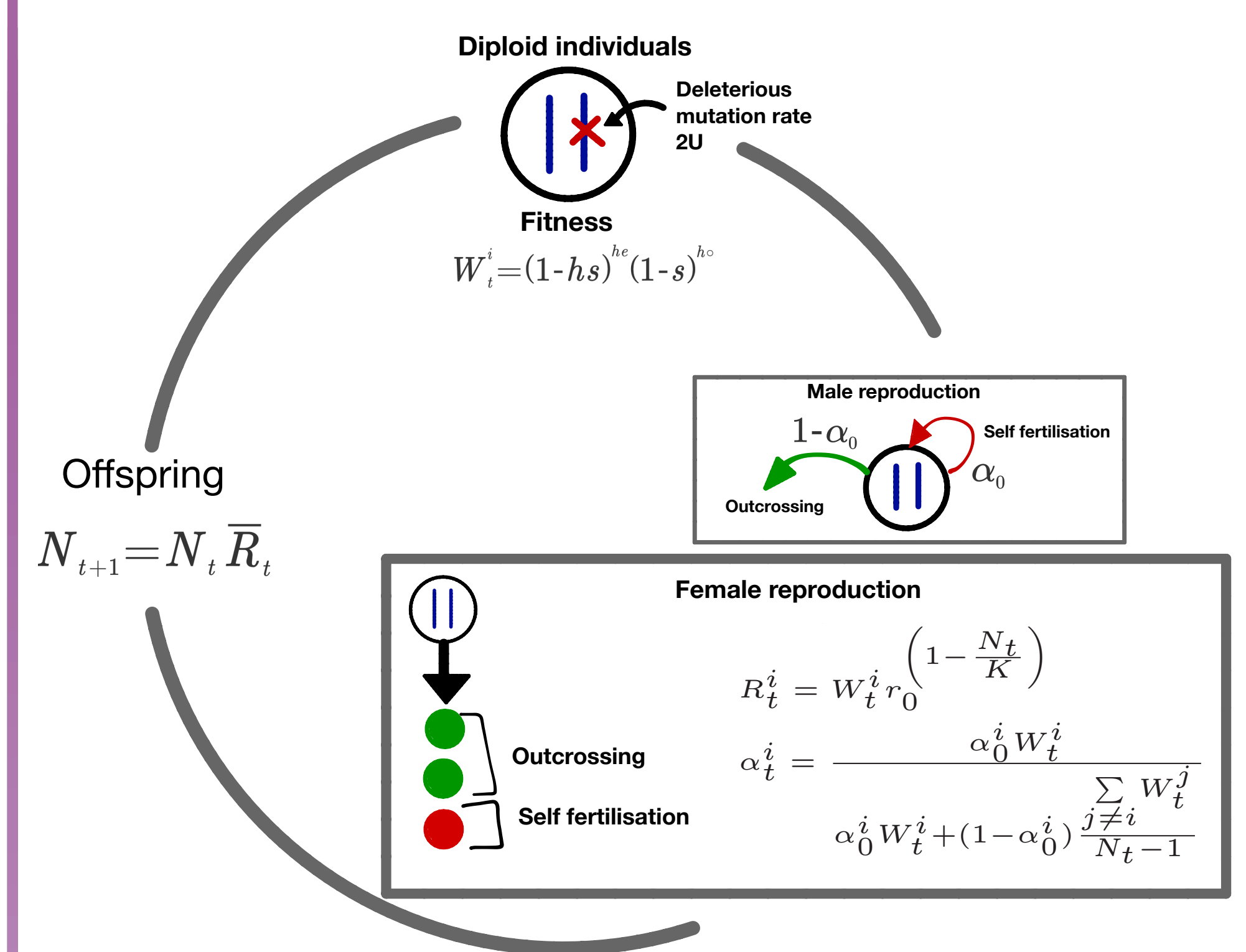
The "dead-end hypothesis" stipulates that self-fertilising lineages are doomed to extinction due to reduced effective population size (Wright et al. 2008) that simultaneously promotes the accumulation of deleterious mutations and the decrease in genetic variation, the latter potentially reducing their adaptive potential to changing environments (Takebayashi and Morrell 2001). However, theoretical works on the evolution of self-fertilisation find that the greater efficacy of the purging of deleterious mutations due to non-random mating favours the evolution for increased rates of self-fertilisation (Lande and Scheske 1985, Charlesworth et al. 1990). The observation of higher extinction rates of self-fertilising lineages compared to outcrossing ones (Goldberg et al. 2010) therefore seems puzzling, and may be due solely to differences in adaptive potential between the two reproductive strategies (Glémin and Ronfort 2013). As population genetics models consider populations of a fixed size, they neglect the potential demographic consequences of the evolution of the rate of self-fertilisation. In this current work we propose an individual-based stochastic model in which population size is a result of the interaction between demography and selection. We have modelled the transition from an initially outcrossing reproductive system to a self-fertilising one due to the introduction of recurrent mutations at a modifier locus and followed the demographic evolution of populations in order to determine whether the change in the reproductive strategy can lead to population extinction.

## Hypotheses



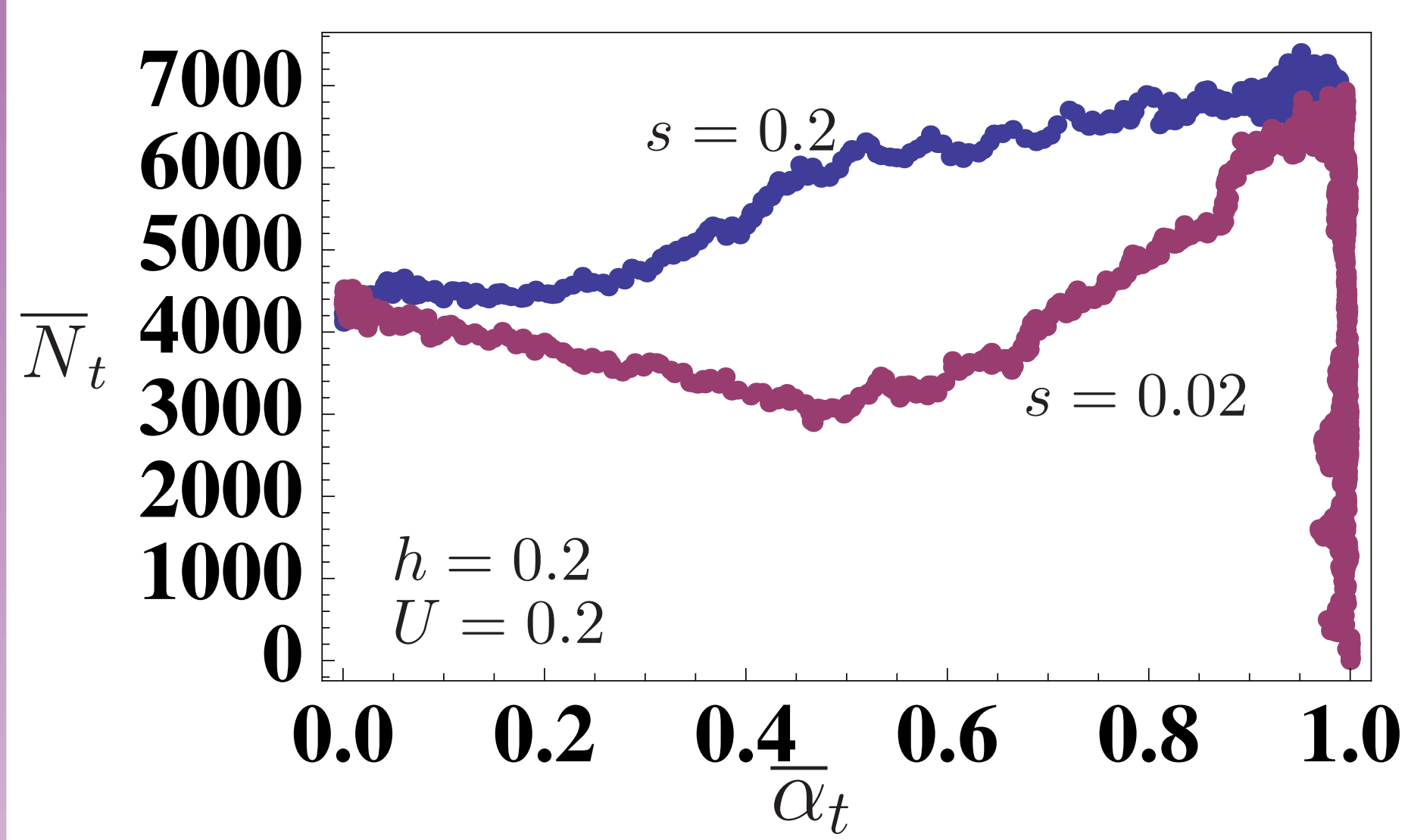
If self-fertilisation at a mean rate  $\bar{\alpha}_0$  can and does evolve in a population (meaning that the level of inbreeding depression is sufficiently small), then there are three possible trajectories a population can follow. If the transition is successful and the rate of self-fertilisation is at equilibrium, either the population is viable (scenario 1), or due to the accumulation of deleterious mutations, the population goes extinct (scenario 2). Another possibility is that during the transition, before the stabilisation of  $\bar{\alpha}_0$ , population size becomes so small that it goes extinct due to demographic stochasticity.

## General model

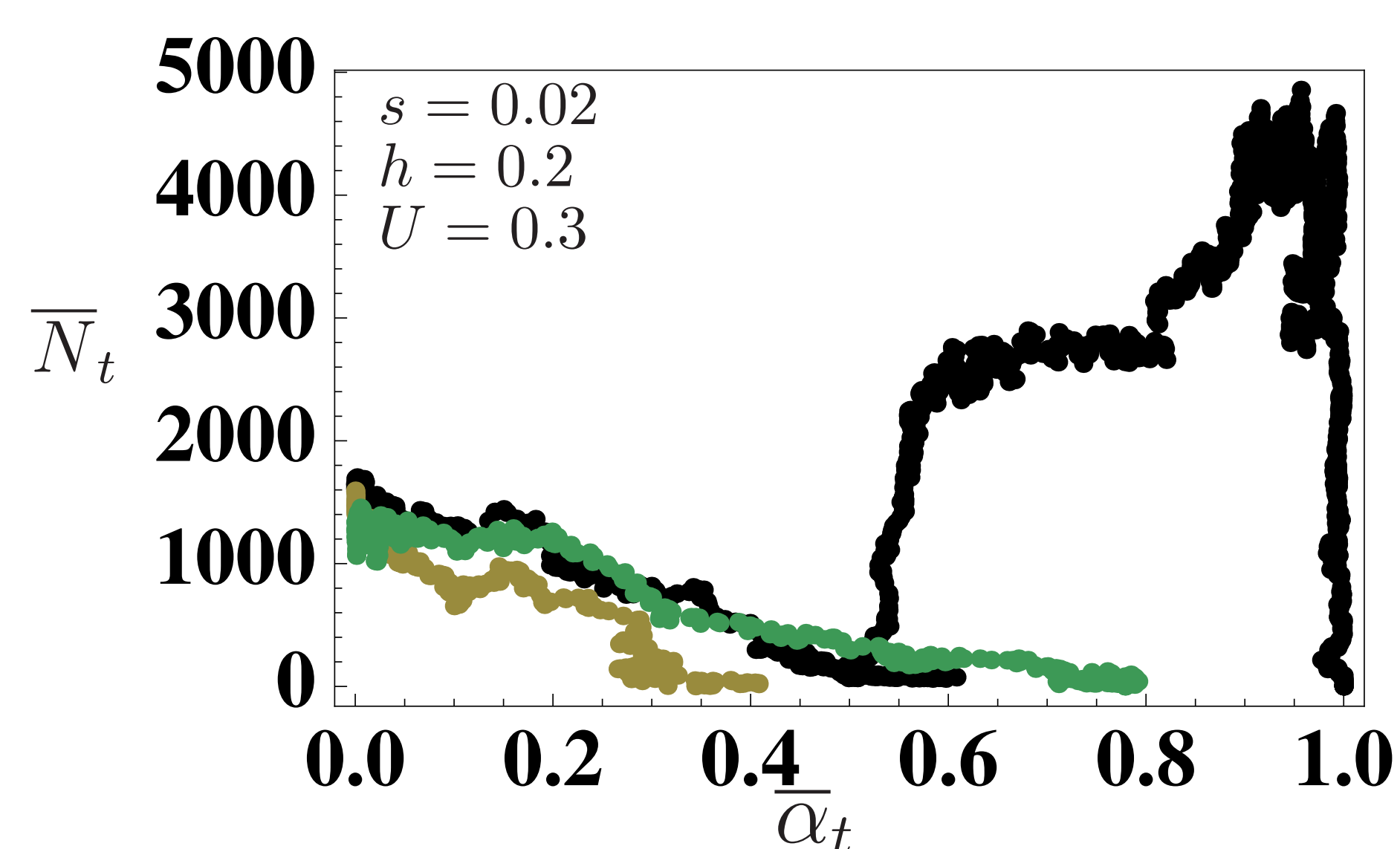


## Results

Stochastic simulation results for a single simulation run. Of the parameters run, when mutations were completely recessive ( $h = 0$ ), self-fertilisation remained close to 0 as the levels of inbreeding depression were very high (over 0.75). When the coefficient of selection  $s = 0.2$  and the dominance  $h = 0.2$ , we only observed the first scenario (see Hypotheses), *i.e.* all populations evolved very high rates of self-fertilisation ( $\bar{\alpha}_t \approx 1$ ) and were viable. Scenarios 2 and 3 were observed exclusively for very mildly deleterious mutations  $s = 0.02$  and  $h = 0.2$ .



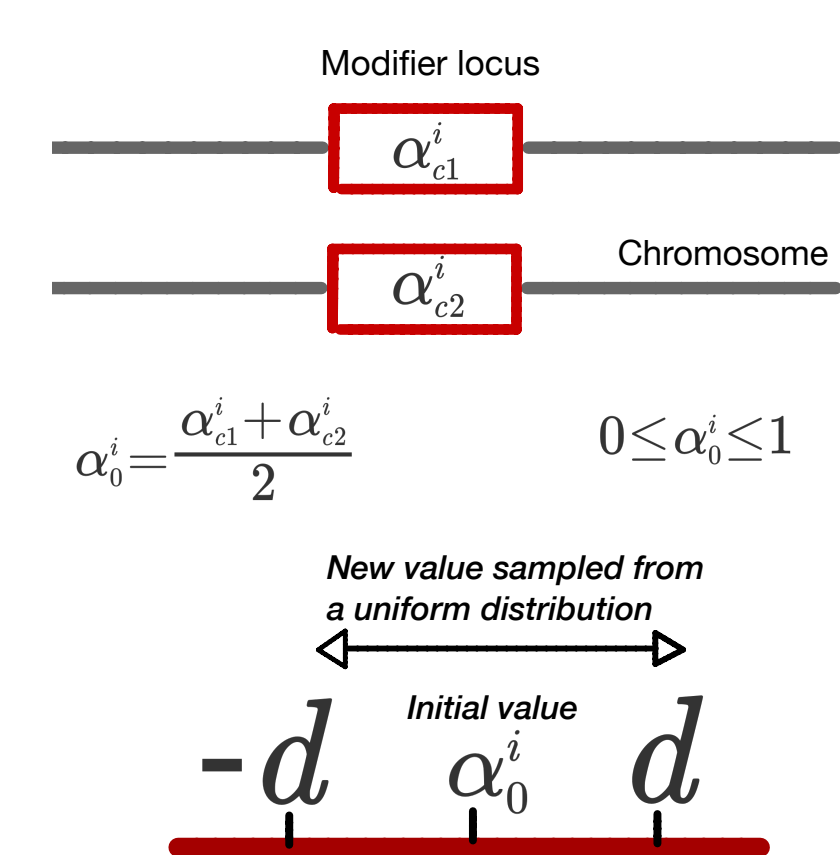
After the successful transition to self-fertilisation (see figure on the left), although we observe viable populations (blue line), there are some cases of evolutionary suicide (purple line). In these simulations, there is the fixation of modifier alleles favouring very high and even strict self-fertilisation. The short term advantage of self-fertilisation (Fisher's automatic advantage, Fisher 1941) leads to extinction in spite of the presence of mutations capable of decreasing the self-fertilisation rate.



The mutational history of a population will influence whether or not a transition to self-fertilisation is successful. On the right three separate simulations are shown for the same parameter values. Populations can either have a successful transition (and as mentioned above we sometimes observe evolutionary suicide, in black) or go extinct before the transition is complete (green and yellow).

Population size  $N_t$  changes from one generation to the next and depends on the mean reproductive rate  $\bar{R}_t = \bar{W}_t r_0^{1 - \frac{N_t}{K}}$ . The reproductive rate is therefore density dependent ( $K$  is the carrying capacity) and is influenced by the mean fitness  $\bar{W}_t$ . Fitness is multiplicative and is calculated using the number of deleterious mutations at the heterozygous ( $he$ ) and homozygous ( $ho$ ) states. Each individual  $i$  has its own relative fitness  $W_t^i$ , reproductive rate  $R_t^i$ . The proportion of self-fertilised ovules produced is defined by  $\alpha_t^i$ .

The evolution of the rate of self-fertilisation:



Mutations at the modifier locus (occurring at a rate  $10^{-3}$ ) lead to new alleles at this locus which can modify the availability of self-pollen  $\alpha_0^i$  for individual  $i$ . The alleles at this locus are co-dominant. The new value of  $\alpha_0^i$  is sampled from a uniform distribution  $(-d, d)$  around the old value, hence either decreasing or increasing it.

## References

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## Discussion

Our results indicate that self-fertilisation can 1) lead to the evolutionary suicide of populations and 2) a potential extinction of populations due to an increased stochasticity (both demographic and genetic) brought on by the change in the self-fertilisation rate and the much decreased effective population size.