Evolutionary rescue under heterozygote Advantage

Tetraploids vs Diploids

Presentation 2024

Theoretical Evolution Research Practical

Rüya and Aigerim

Overview

1. Our question and Why
2. Hypothesis
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4. How does our model work
5. Fitness landscape model
6. Parameters & Results
7. Genotype Breakdown: Punnett Square Analysis
8. Mechanisms behind tetraploid advantage
9. Limitations

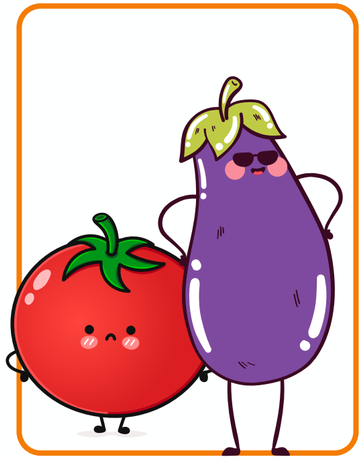
How Does ploidy level affect a population's ability to survive under selection pressure?

- focus on Heterozygote advantage.
- polyploidy is underrepresented in the field.

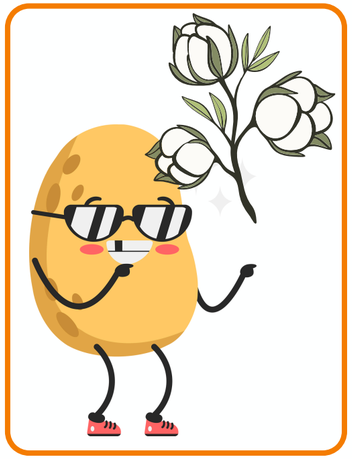
polyPloidy in plants

- Polyploidy is common in plants and increases genetic variability.
- Learning about how ploidy effects evolutionary rescue is relevant for agriculture and conservation.

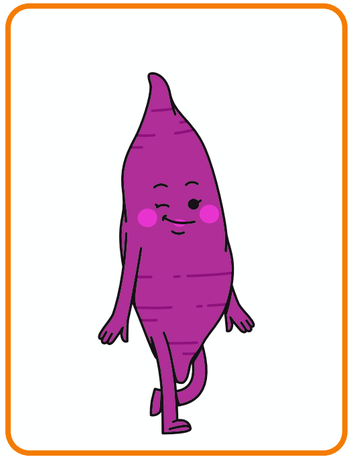
diploid



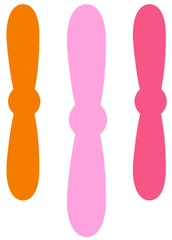
tetraploid



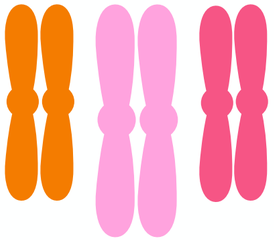
Hexaploid



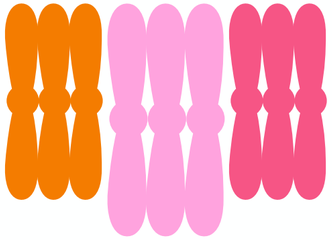
Haploid



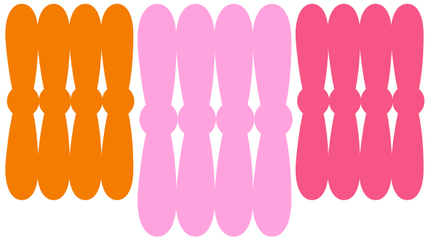
diploid



triploid



tetraploid



Hypothesis:

Tetraploids Have an Advantage

genetic buffering

Tetraploids have “genetic buffering”

especially powerful in the case of heterozygote advantage

genotype combinations

Tetraploids have wider range of genotype combinations.

augmented mutations

tetraploids have double the rate of mutations due to the number of allels.

commonness

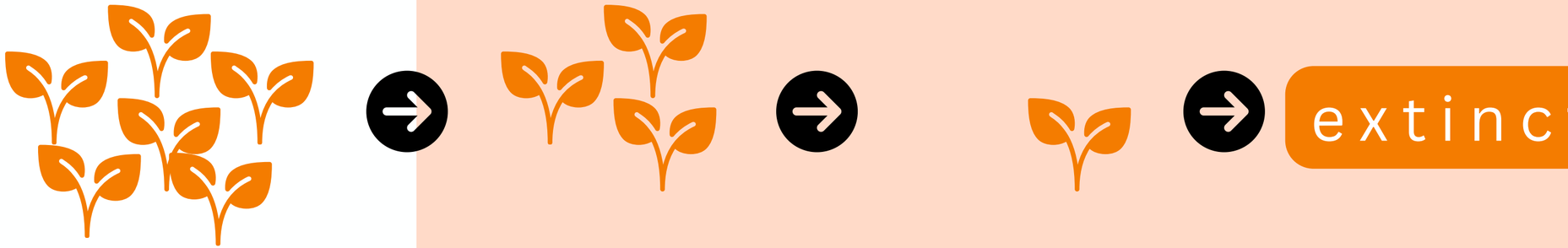
Extinction/Rescue model

hebicide

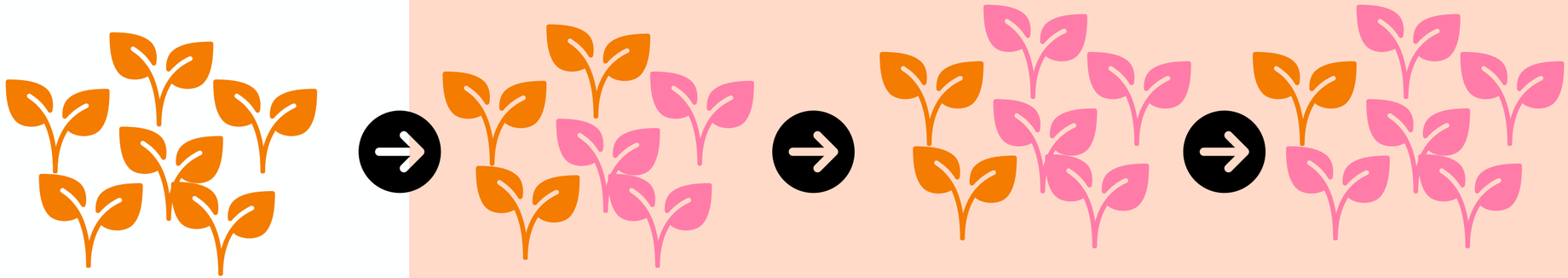
not resistant
(rr & RR)

resistant
(Rr)

diploid



extinction.



rescue

hebicide

not resistant
(rr & RR)

resistant
(Rr)

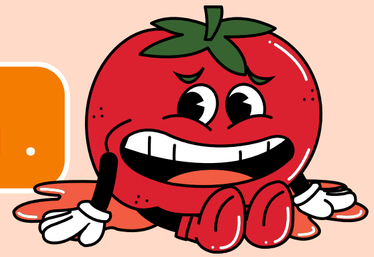
diploid

r | r r | r r | r r | r r | r r | r

r | r r | r r | r

r | r

extinction.



r | r r | r r | r r | r r | r r | r

r | r r | r R | r

R | r R | R

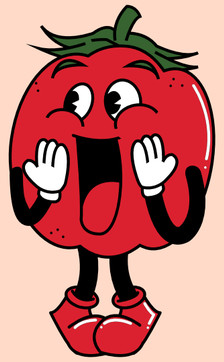
r | r r | R | r

R | r R | R

r | r r | R | r R | r R | r

R | r R | R

survival

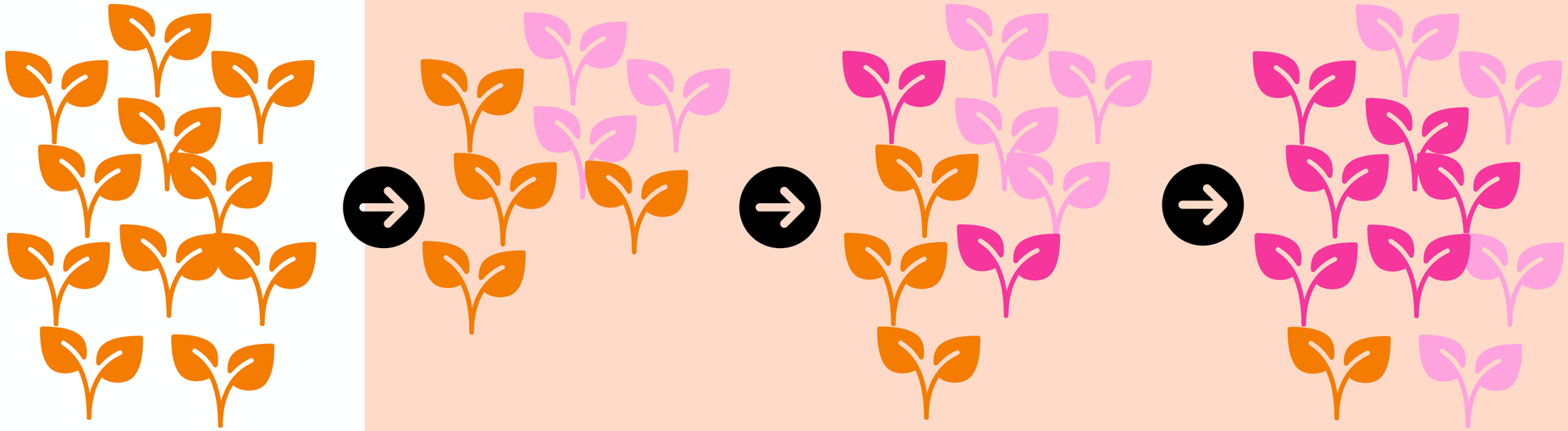


hebicide

not resistant (rrrr & RRRR)

medium-resistant (Rrrr, RRRr)

high- resistant (RRrr)



tetraploid

hebicide

not resistant (rrrr & RRRR)

medium-resistant (Rrrr, RRRr)

high- resistant (RRrr)

tetraploid

r | r | r | r

r | r | r | r

r | r | r | r

r | r | r | r

r | r | r | r

r | r | r | r

r | r | r | r

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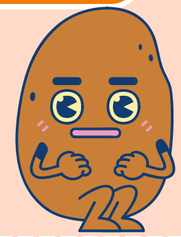
r | r | r | r

r | r | r | r

r | r | r | r

extinction.



r | r | r | r

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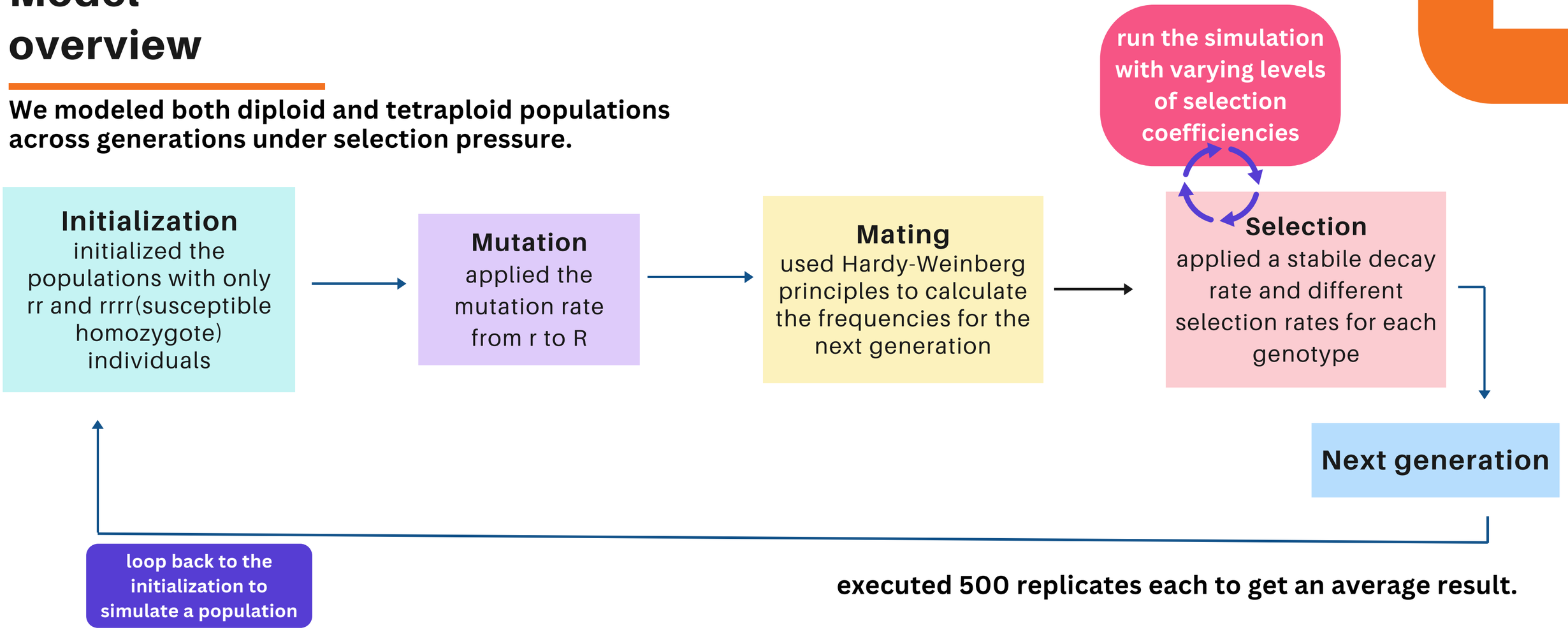
R | R | R | R

survival

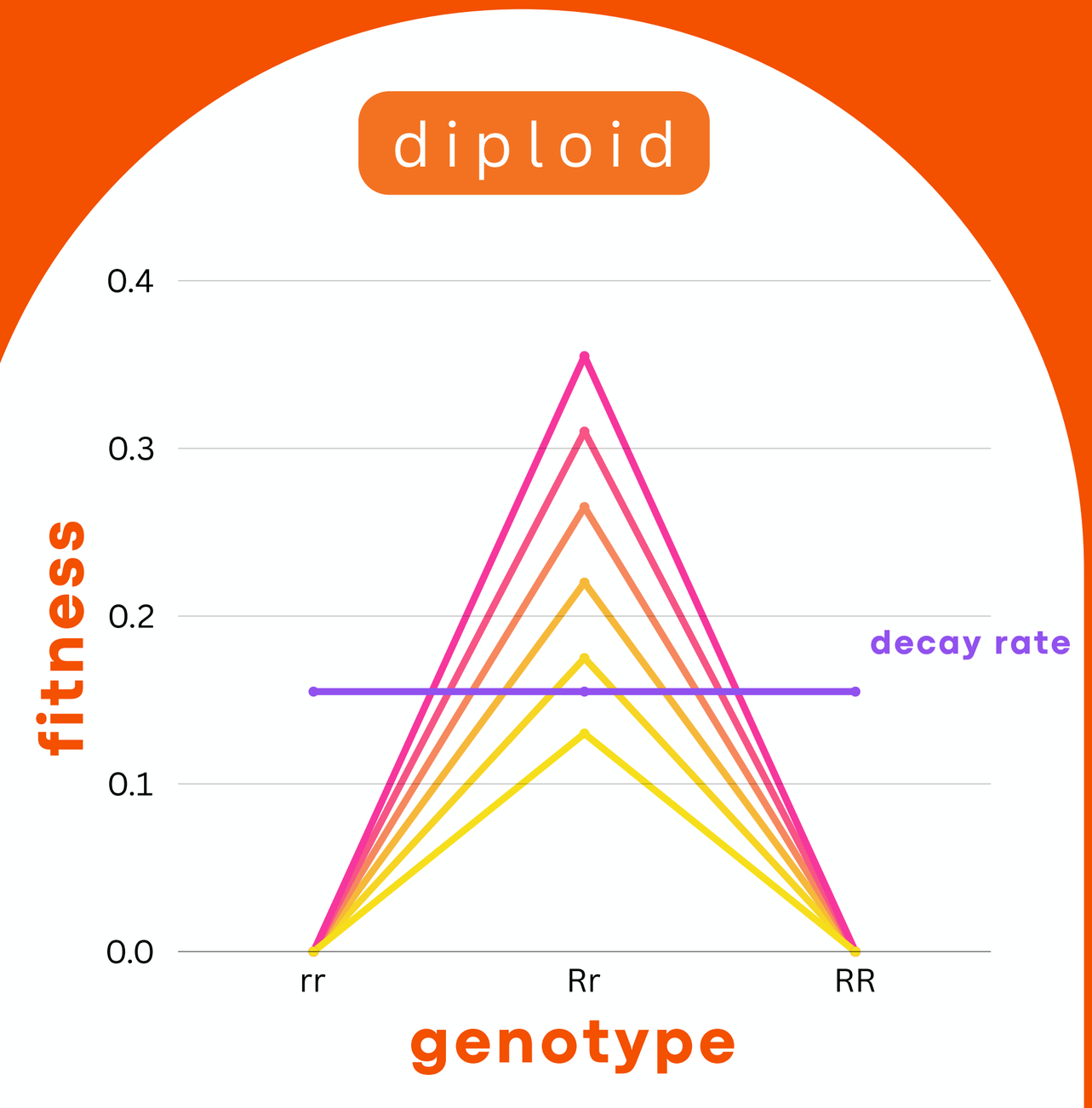
Model overview

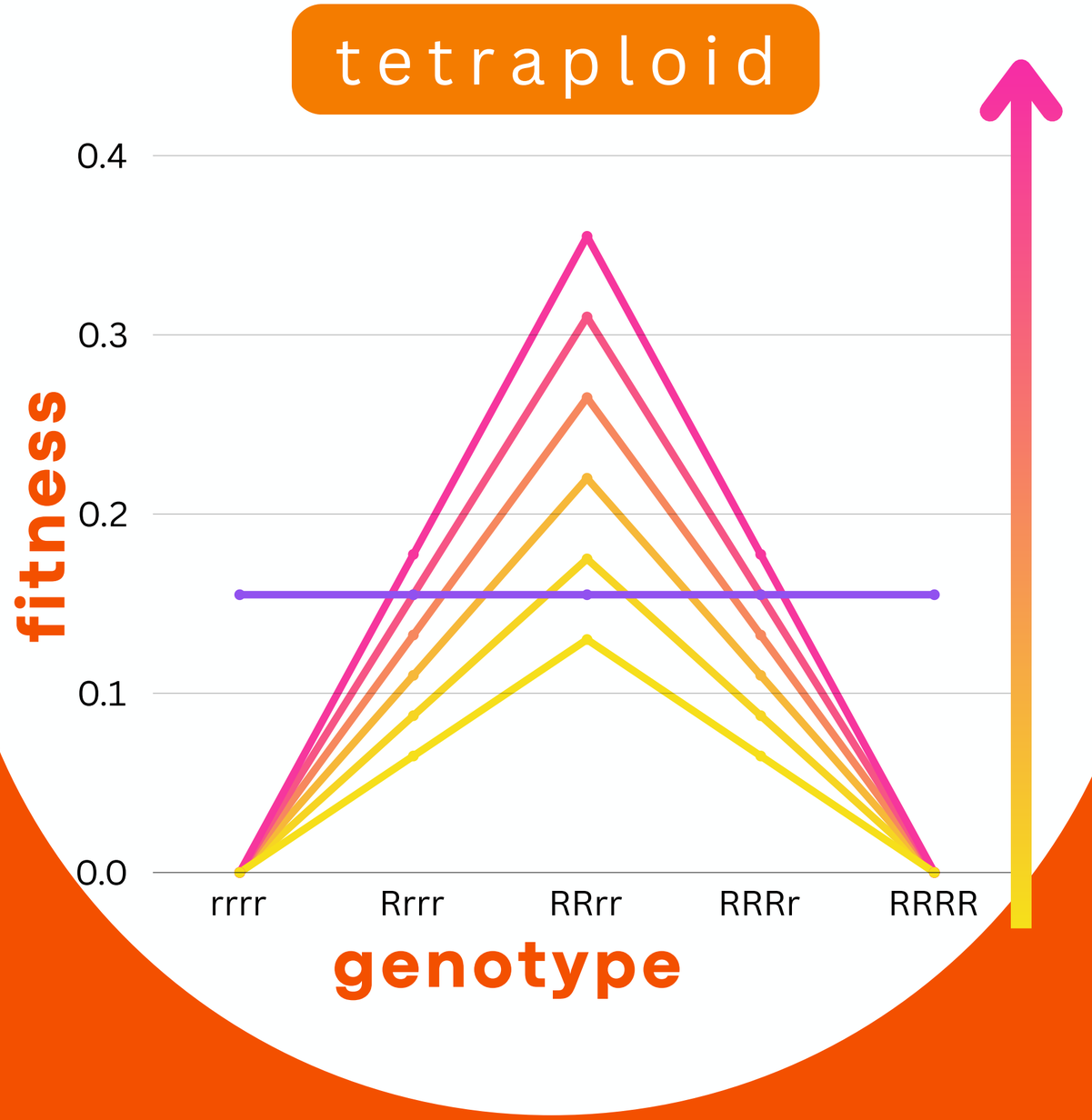
We modeled both diploid and tetraploid populations across generations under selection pressure.



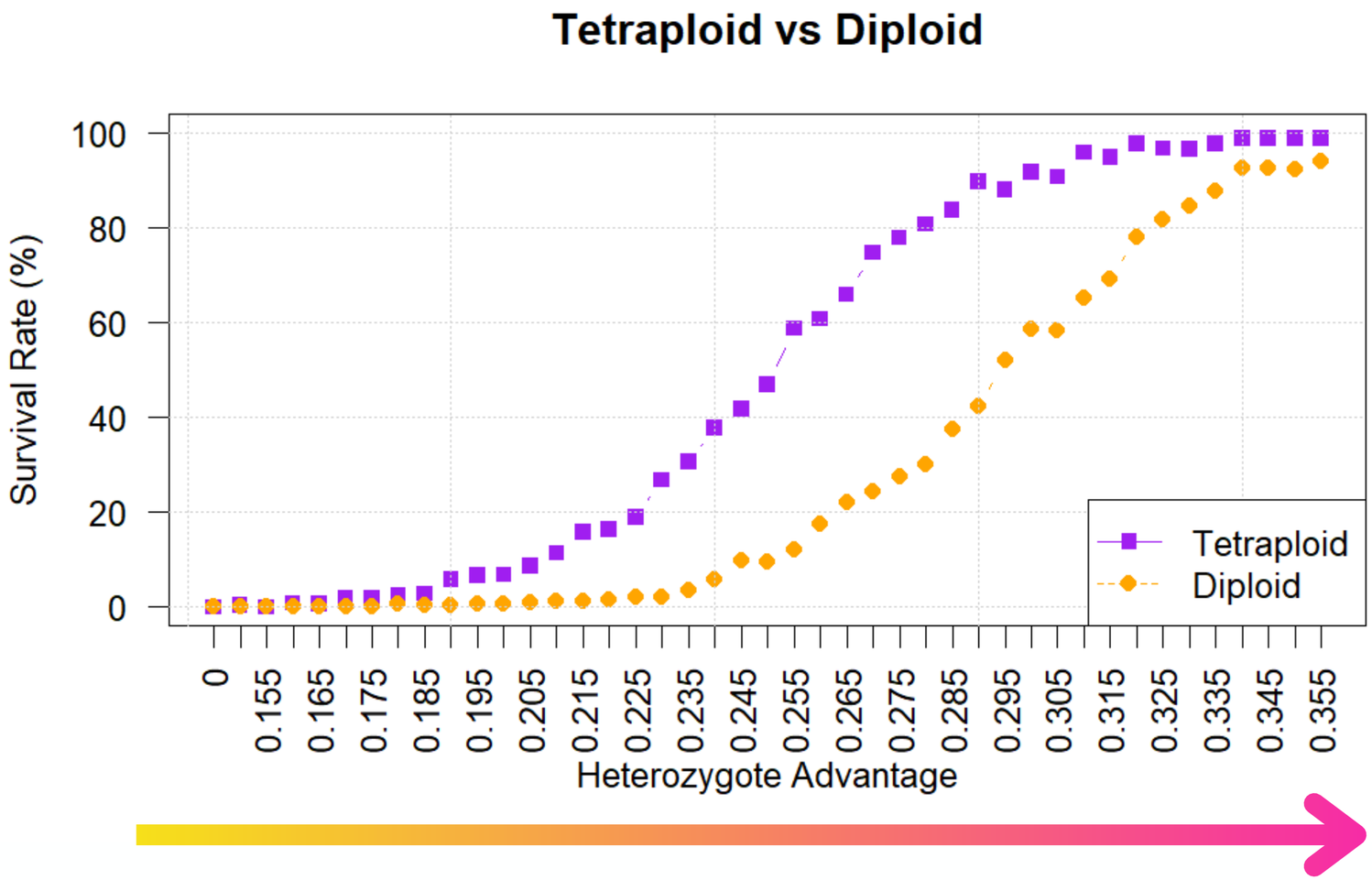
executed 500 replicates each to get an average result.

Fitness landscape





Results

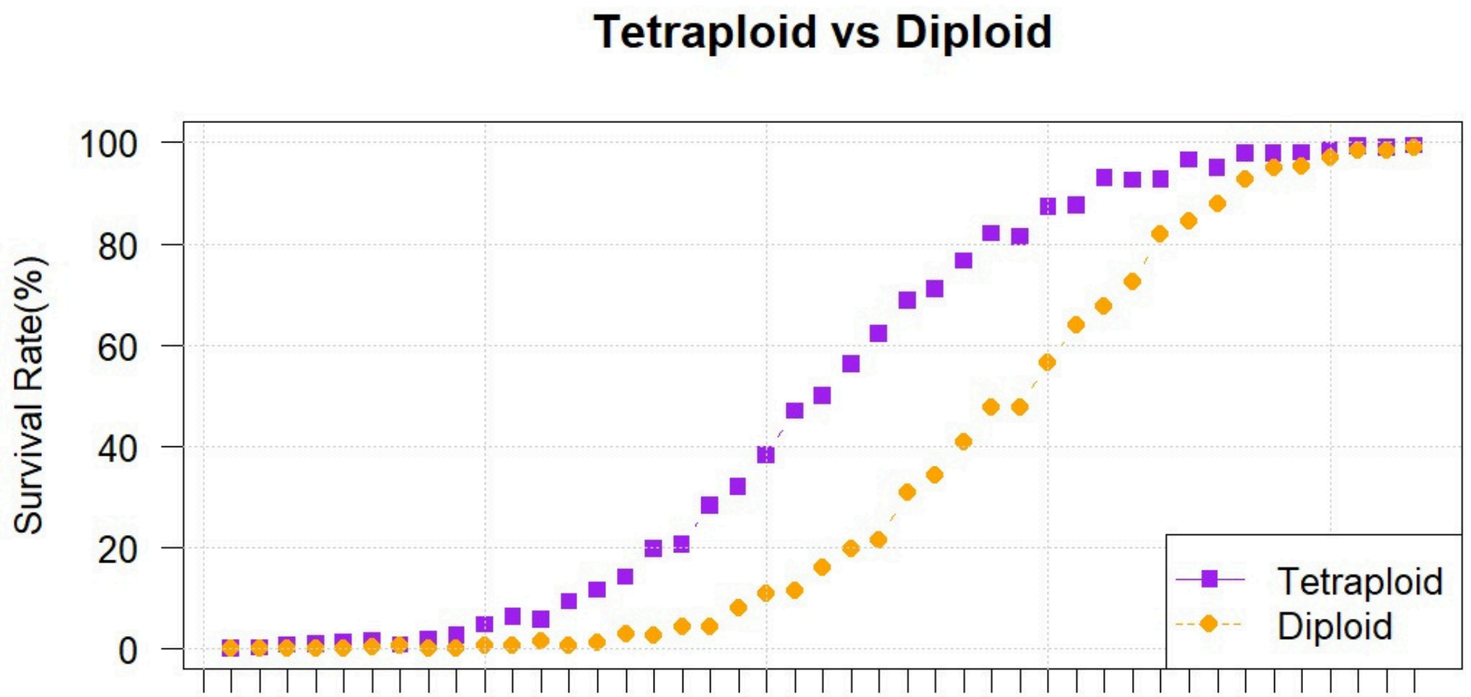


parameters

mutation rate	0.01
maximum generation	100
decay rate	0.155
replicates	500
initial population	rr = 250 & rrrr = 250

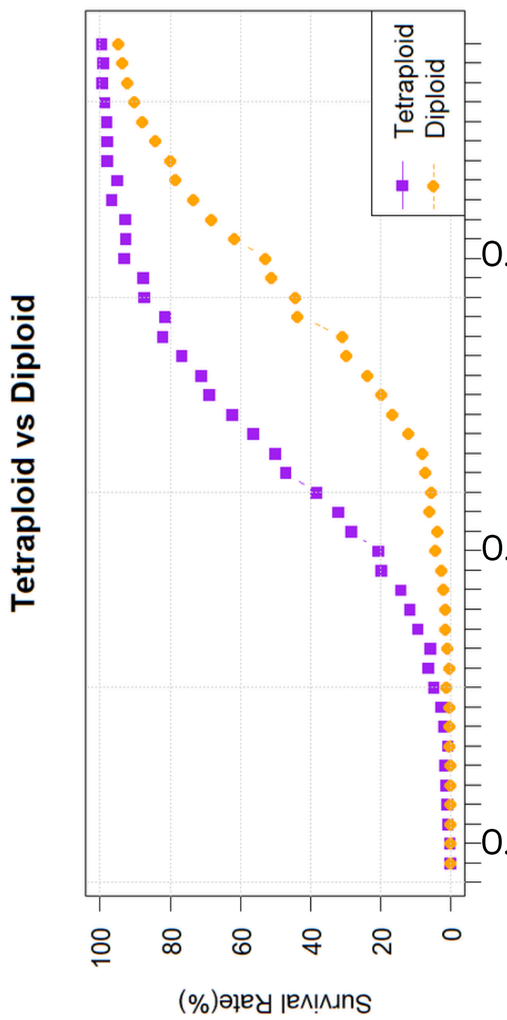
Results & given double mut to diploids

To see if this difference is only due to double the mutation in tetraploids, we gave double the mutation rate to diploids and compared.



Diploids performed better, but seems like there is more to the tetraploid success.

Results


Tetraploid vs Diploid
Tetraploid
Diploid
Survival Rate(%)
100
80
60
40
20
0


0.4
0.3
0.2
0.1
0.0
rrrr
Rrrr
RRrr
RRRr
RRRR

Genotype Breakdown: Punnett Square Analysis

tetraploid

Tetraploid Punnett squares show more genotype combinations, with a larger proportion of resistant genotypes.

RRrr x RRrr	RR	Rr	Rr	rr
RR	RRRR	RRRr	RRRr	RRrr
Rr	RRRr	RRrr	RRrr	Rrrr
Rr	RRRr	RRrr	RRrr	Rrrr
rr	RRrr	Rrrr	Rrrr	rrrr

= 2/16

= 1/2

= 6/16

diploid

Rr x Rr	R	r
R	RR	Rr
r	Rr	rr

= 1/2

= 1/2

50% high-resistant, 50% non-resistant.

Tetraploids: Only 2/16 non-resistant, with majority showing some level of resistance.

not resistant
(rrrr & RRRR) (rr & RR)

medium-resistant
(Rrrr, RRRr)

high- resistant
(RRrr) (Rr)

Why Tetraploids Perform Better?

Mechanisms Behind Tetraploid Advantage

genetic buffering

Tetraploids have “genetic buffering”, and this helps them especially in the case of heterozygote advantage.

genotype combinations

Tetraploids have wider range of genotype combinations.

augmented mutations

tetraploids have double the rate of mutations due to the number of allels.

Limitations

Hardy weinberg

All the asumptions made for the hardy weinberg equilibriums apply to our model. We did not take into consideration how long it takes to reach the hardy weinberg equilibrium, we applied it for each generation.

Extinction vs rescue

We simply considered a population that did not went extinct as rescued, which might not be the case at all times.

Future Research Steps

Extend the model to other fitness landscape models eg. additive.

Incorporate environmental variations and real-world data to refine predictions.

Thank you for your attention.

ANY QUESTIONS?

RÜYA &
AIGERIM