BIOL 01104, Fall 2019
Evolutionary Forces Simulation Lab
Instructor: Dr. Spielman

Instructions

For this activity, you will examine how evolutionary forces affect allele frequencies and fitness in populations using a browser-based software called **evolfoRces**.

- If you are connected to wifi specifically via the RowanSecure network (yes, this is the link - use this when on campus): http://10.33.168.74:3838/biol01104-apps/evolfoRces/inst/evolfoRces/
- Any wifi network (i.e. use from home here): https://sjspielman.shinyapps.io/evolfoRces/

In evolfoRces, you can evolve a population which has a single gene controlled by two alleles, ***A*** and ***a*** ("big A" and "little a"). Please refer to the "About and Help" tab for a description of what each tab does. We will use the "Single Population" tab for Parts 1-5 of this lab, and the "Migration" tab for Part 6 of this lab.

The goal of this activity is to understand how different evolutionary forces affect allele frequencies and population fitness over time. For any simulation, allele *A*'s frequency will either change over time, or it won't change over time. Here are some options for what can happen:

1. **Allele *A* will fix in the population.** This means allele *a* is lost from the population.
2. **Allele *A* will be lost from the population**. This means allele *A* fixes in the population.
3. **Allele frequencies will reach a stable equilibrium over time**, i.e. allele frequencies will not change. This means evolution is not occuring (but, as we will see, there are many different ways to achieve equilibrium some of which involve a "balance" between evolutionary forces!).
4. **Allele frequencies will not reach a stable equilibrium over time**, i.e. evolution will be ongoing and allele frequencies will continue changing. This can happen either when fixation/equilibrium will occur but requires more generations, or fixation/equilibrium will not occur and the population will "forever" remain unstable.
    a. ***HINT!!!*** *To check if a population has reached equilibrium, re-run the simulation with more generations and see if results are consistent. If consistent, populated has reached equilibrium.*

There are several pieces of information which we can observe from population simulations that help us to further understand how alleles change in frequency over time, including:

- If fixation occurs, how many generations did it take?
- If fixation does not occur, does the population reach an equilibrium or continue to evolve?
- What is the effect of the starting allele *A* frequency?
- How do different scenarios influence population variation, as measured by heterozygosity?
- How do different scenarios influence population mean population fitness?

You do NOT need to submit these tables, but you ARE responsible for all information and associated discussion!! Take careful notes!!

Part 1: Natural selection

- 250 generations
- Mutation rates set to 0
- Genetic drift turned OFF

Starting Allele A frequency	W(AA)	W(Aa)	W(aa)	Mode of selection?	Fate of population: • "A" Fixation • "A" Loss • Equilibrium • No equilibrium	If fixation/loss, which generation?	Starting fitness (approx. from graph)	Final fitness	Final het.
0.5	1	0.9	0.8						
0.2	1	0.9	0.8						
0.8	1	0.9	0.8						
0.5	1	0.6	0.2						
0.5	0.8	1.0	0.8						
0.2	0.8	1.0	0.8						
0.8	0.8	1.0	0.8						
0.5	1.0	0.8	1.0						
0.2	1.0	0.8	1.0						
0.8	1.0	0.8	1.0						

Part 2: Mutation under directional selection

- Use a starting allele A frequency of 0.5. *This means starting heterozygosity is always 50%.*
- Set genotype fitnesses to *directional selection:* AA = 1.0; Aa = 0.9; aa = 0.8
- 250 generations
- Genetic drift turned OFF

A→ a mutation rate	**a → A mutation rate**	**Fate of population:** • **"A" Fixation** • **"A" Loss** • **Equilibrium** • **No equilibrium**	**If fixation/loss, which generation?**	**Starting fitness (approx. from graph)**	**Final fitness**	**Final heterozygosity**
0.05	0					
0	0.05					
0.05	0.05					

Part 3: Mutation under balancing selection

- Use a starting allele A frequency of 0.5. *This means starting heterozygosity is always 50%.*
- Set genotype fitnesses to *balancing selection (but with a slight fitness advantage for A over a):* AA = 0.8; Aa = 1.0; aa = 0.75
- 250 generations
- Genetic drift turned OFF

a→ A mutation rate	**A → a mutation rate**	**Fate of population:** • **"A" Fixation** • **"A" Loss** • **Equilibrium** • **No equilibrium**	**If fixation/loss, which generation?**	**Starting fitness (approx. from graph)**	**Final fitness**	**Final heterozygosity**
0.05	0					
0	0.05					
0.05	0.05					

Part 4: Genetic drift (i.e., the effect of population size)

- Use a starting allele A frequency of 0.5. *This means starting heterozygosity is always 50%.*
- Turn OFF natural selection by setting fitness: AA = 1.0; Aa = 1.0; aa = 1.0
- 250 generations
- Genetic drift turned ON! Specify 10 replicate populations.

N (population size)	**# replicates where allele *A* fixed**	**Range of generations for "A" fixation** (write "min-max"; ie 10-50)	**# replicates where allele *a* fixed**	**Range of generations for "a" fixation**	**# replicates where *no fixation* occurred**	**Range of allele A frequencies where no fixation occurred**	**Range of final het. for all replicates**
10							
25							
50							
100							
500							
1000							
10000							
100000							

Part 5: Natural selection and genetic drift

- Use a starting allele A frequency of 0.5. *This means starting heterozygosity is always 50%.*
- 250 generations
- Genetic drift turned ON! Specify 10 replicate populations**.**
- Note: each simulation considers directional selection, at different strengths, similar to Part 1 of this activity. Compare your answers here back to part 1 for insights into how and when genetic drift can "counter" the effects of selection.

N	**W(AA)**	**W(Aa)**	**W(aa)**	**# reps where allele *A* fixed**	**Range of generations for "A" fixation**	**# reps where allele *a* fixed**	**Range of generations for "a" fixation**	**# reps where *equilibrium* occurred**	**# reps where *no equilibrium and no fixation* occurred**	**Final fitness range**	**Final het. range**
10	1	0.9	0.8								
25	1	0.9	0.8								
100	1	0.9	0.8								
1000	1	0.9	0.8								
10	1	0.6	0.2								
25	1	0.6	0.2								
100	1	0.6	0.2								
1000	1	0.6	0.2								
10	1	0.99	0.98								
25	1	0.99	0.98								
100	1	0.99	0.98								
1000	1	0.99	0.98								

Part 6: Migration and selection

- **Continent** fixed allele A frequency = 0.8
    - This means 80% of alleles arriving to the island via migration (aka gene flow) will be "A".
- Starting **island** allele A frequency = 0.5. *This means the starting heterozygosity is always 50%.*
- 250 generations

W(AA)	W(Aa)	W(aa)	Migration rate (% islanders who are migrants)	Mode of selection	Fate of population: • "A" Fixation • "A" Loss • Equilibrium • No equilibrium	If fixation/loss, which generation?	Starting fitness (approx. from graph)	Final fitness	Final het.
1	1	1	0.05						
1	1	1	0.1						
1	1	1	0.3						
1	0.9	0.8	0.1						
0.8	0.9	1	0.1						
0.8	1	0.8	0.1						