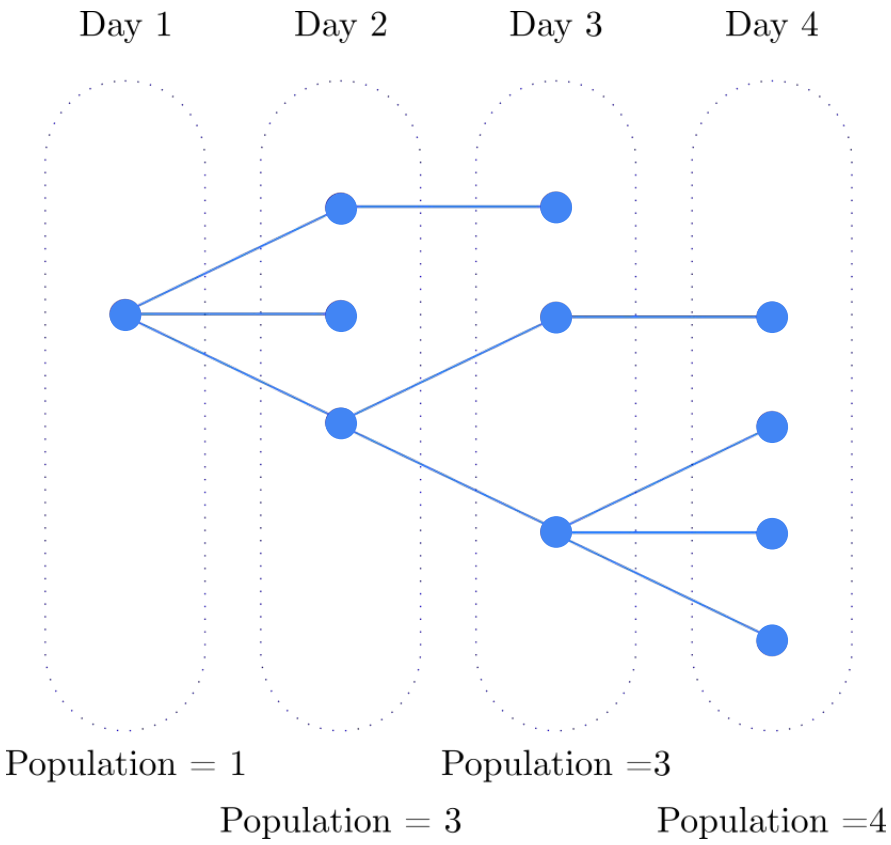
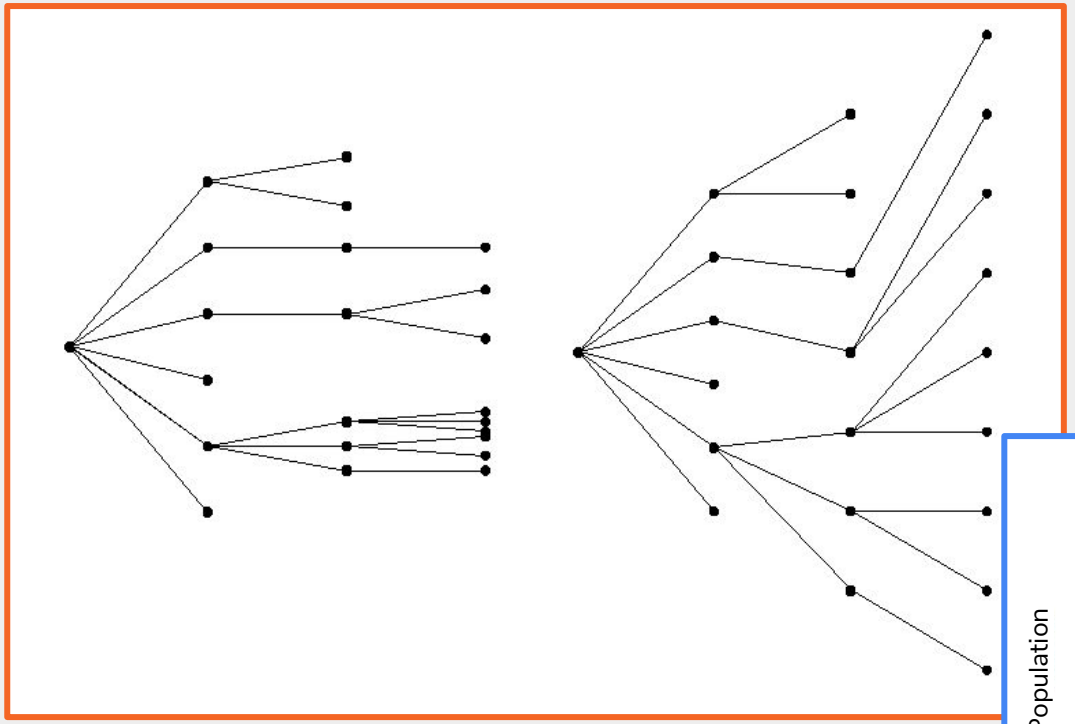
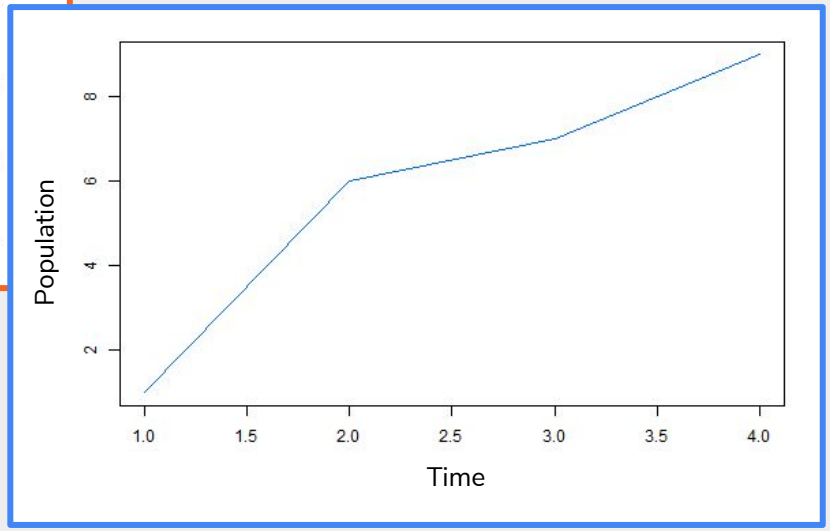
Simulating Branching Processes in R

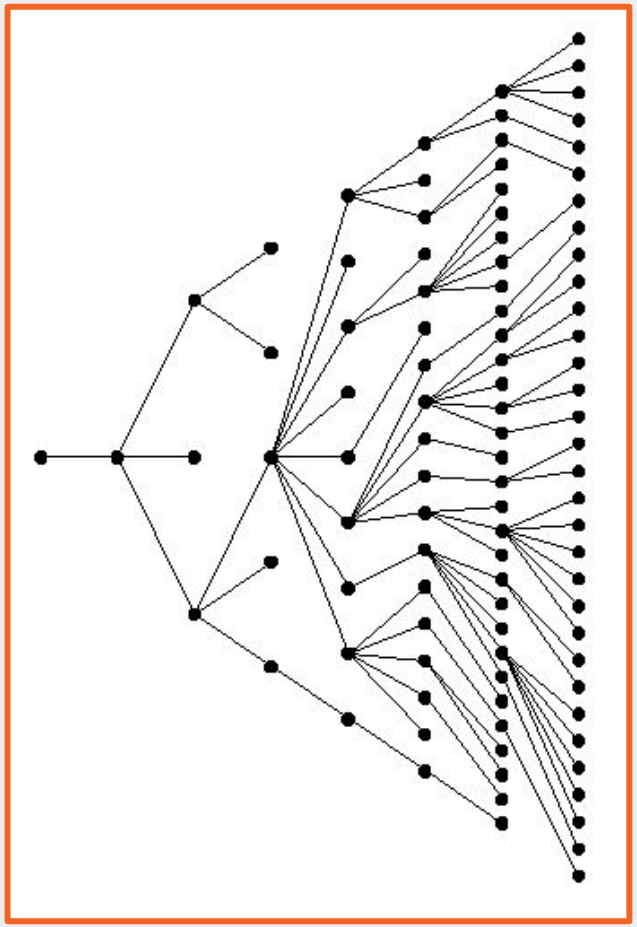
Alice Hankin - Summer Research Scholarship 2020/21


Day 1
Day 2
Day 3
Day 4
Population = 1
Population = 3
Population =3
Population =4

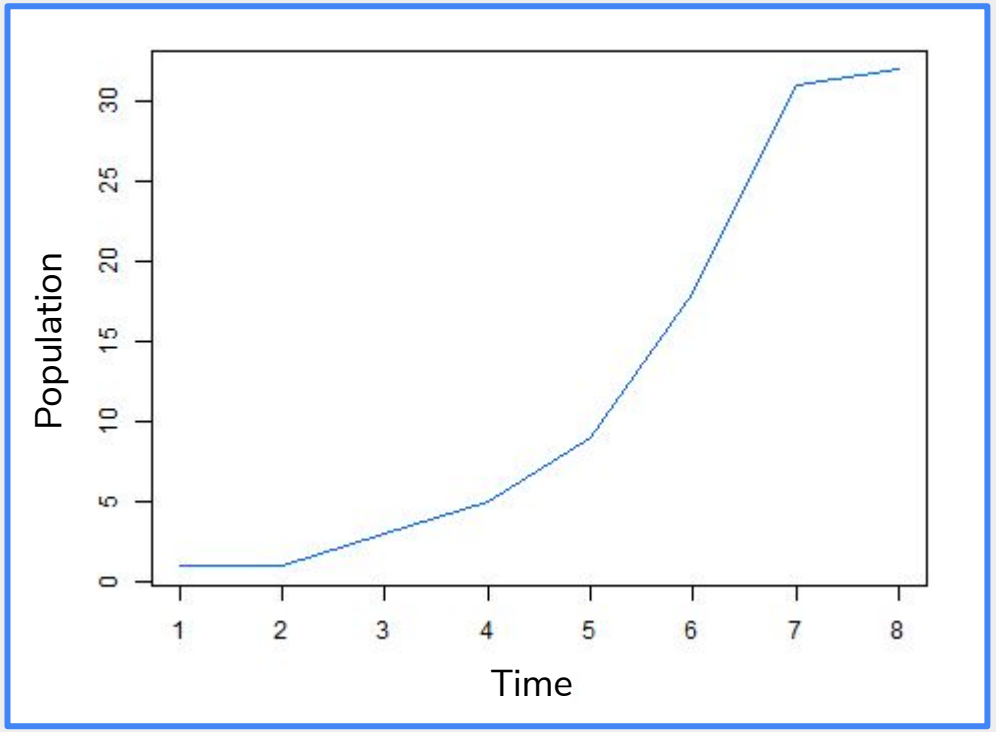


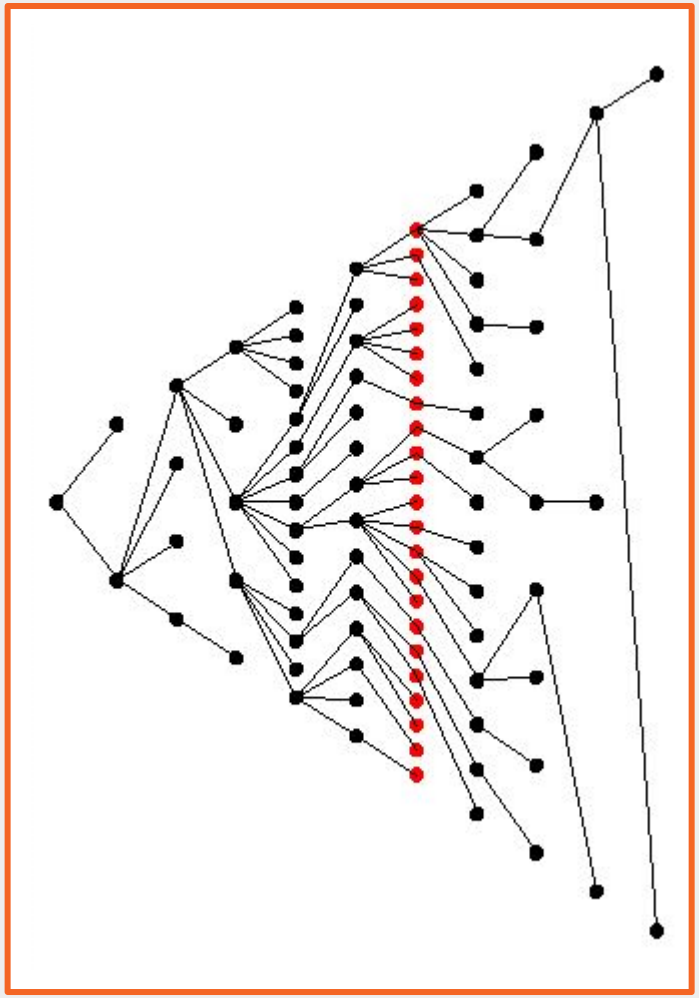
Offspring distribution has a geometric distribution with a mean of 1.5





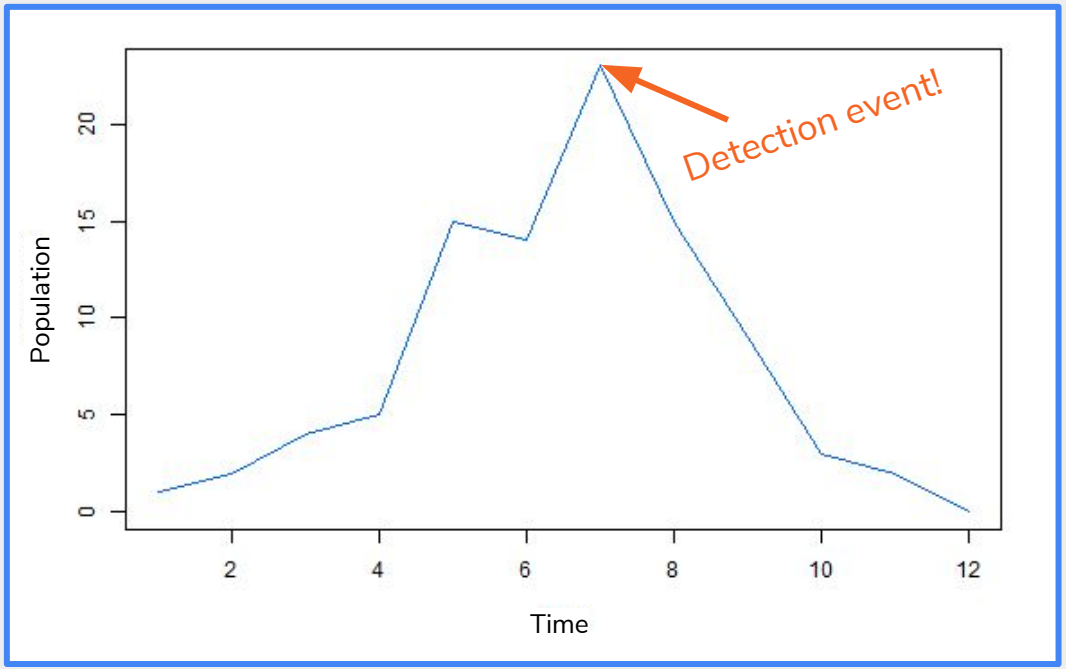
Offspring distribution ~ geometric with a mean of 1.5

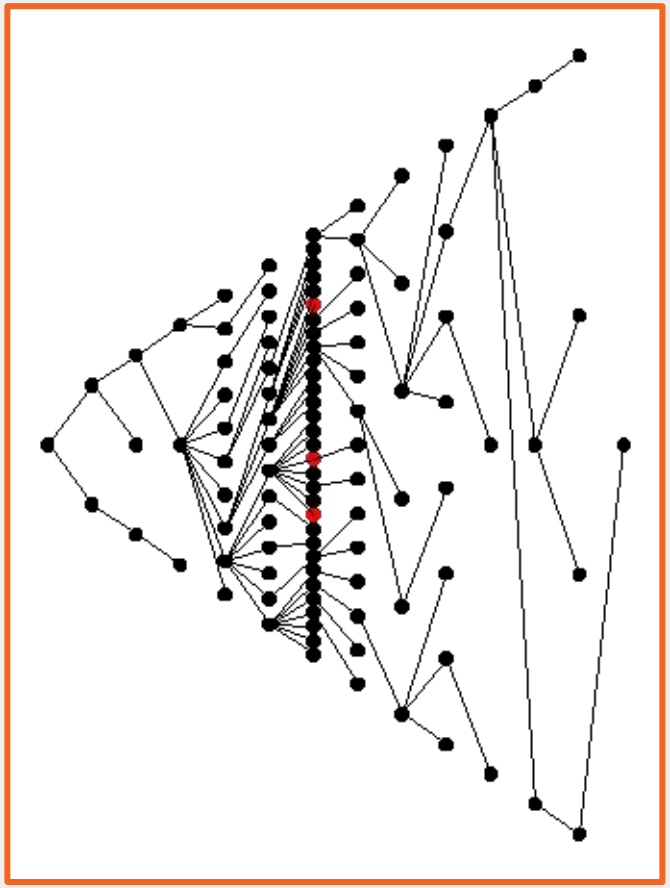


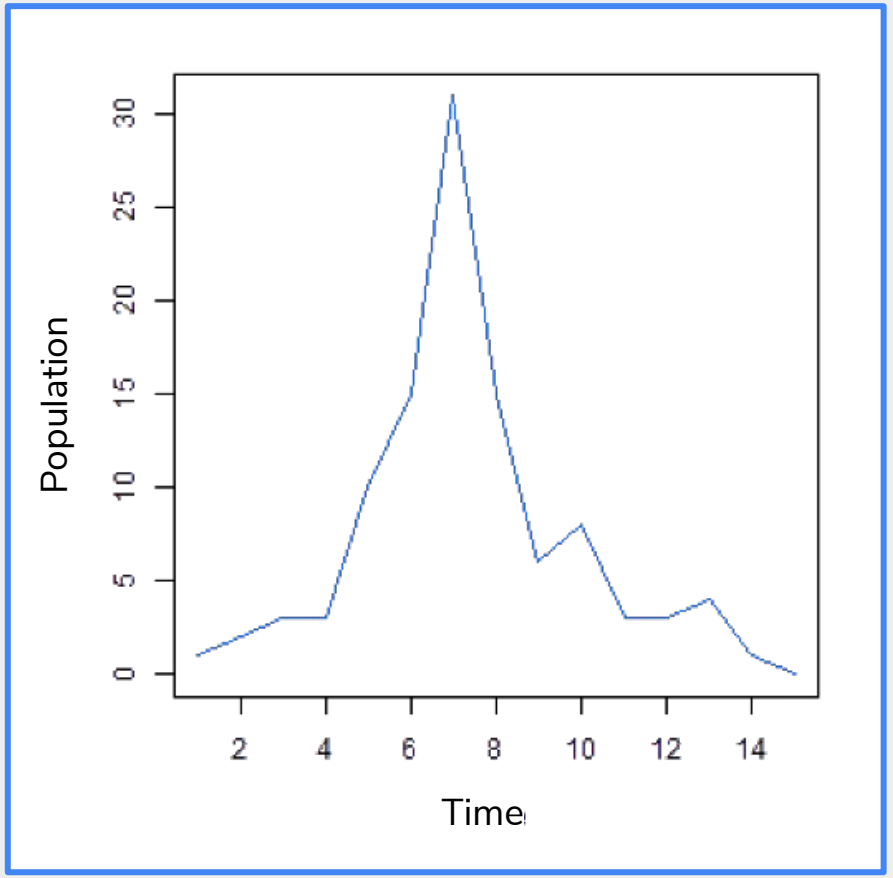


Initial distribution ~ geometric with mean 1.4

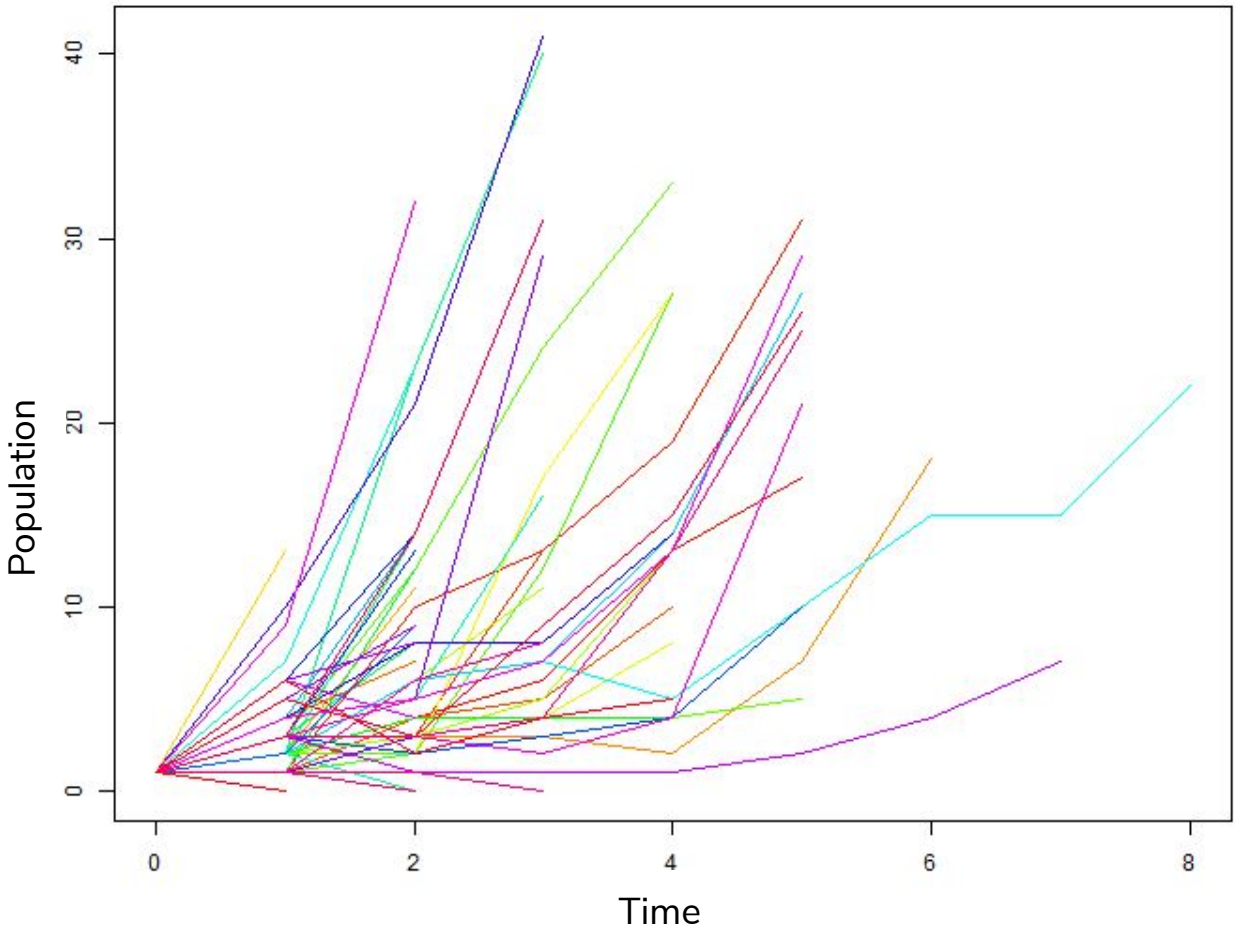
Distribution after detection (at generation 7) ~ geometric with mean 0.8







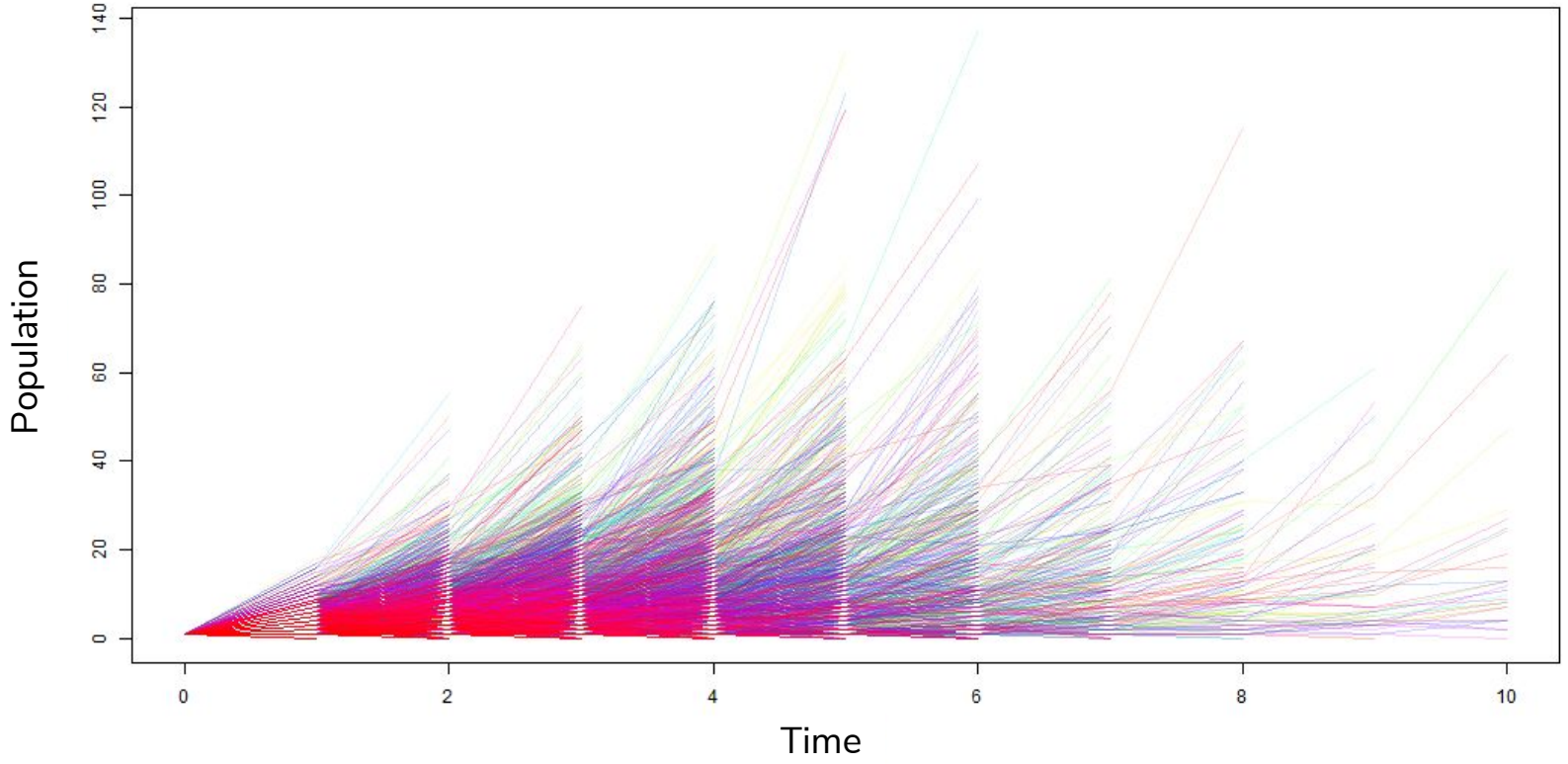
https://alicemh.shinyapps.io/tree/

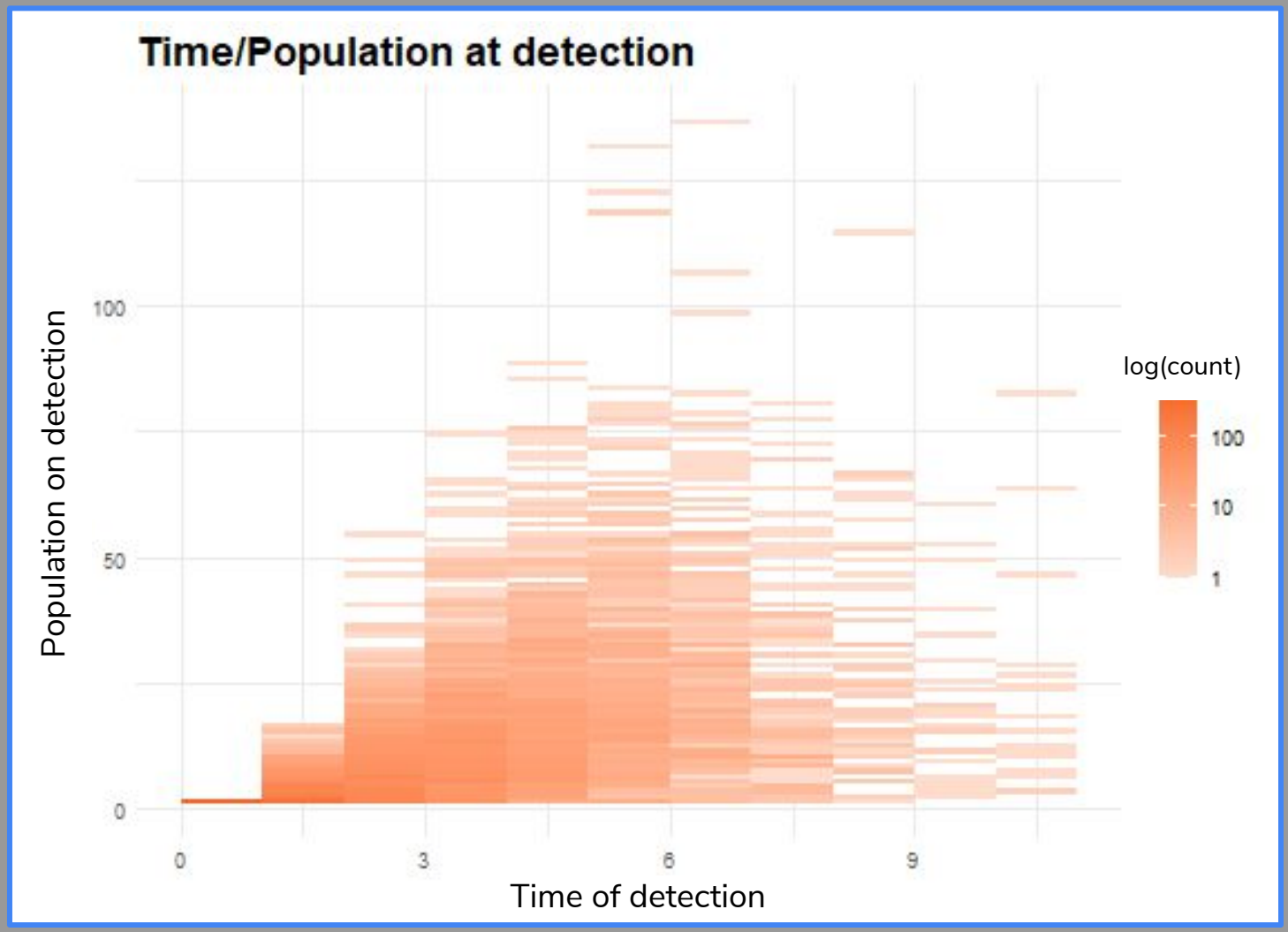


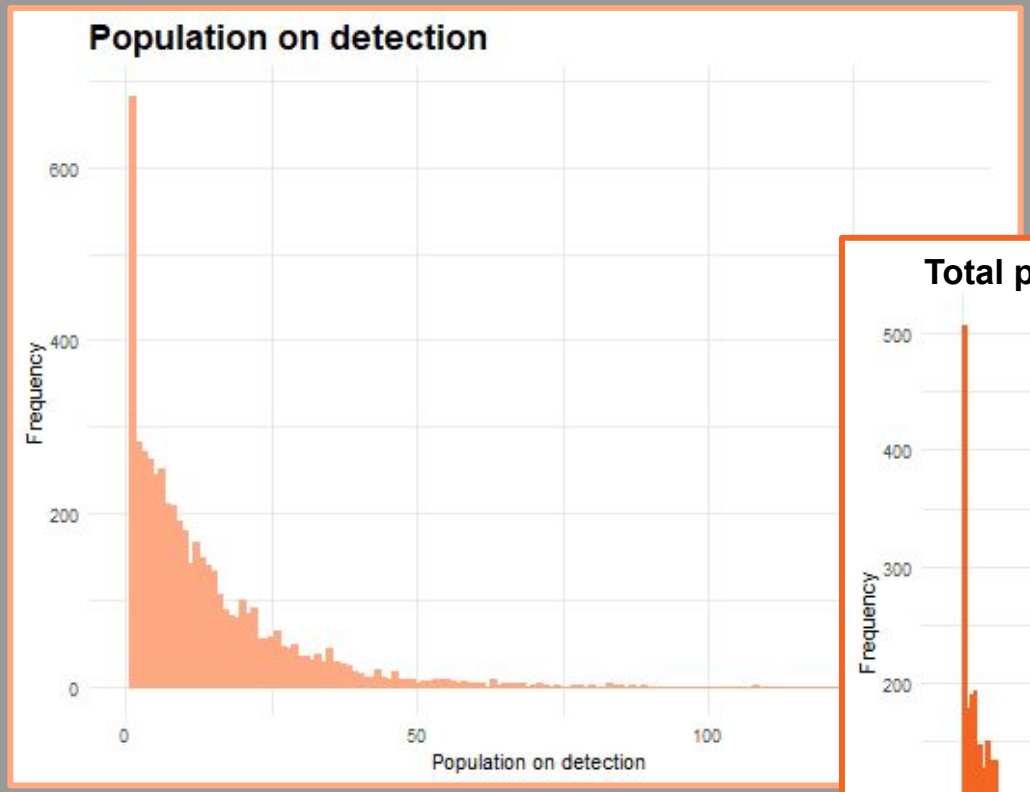
The offspring distribution has a geometric parameter of 0.35 (mean of ~1.86)

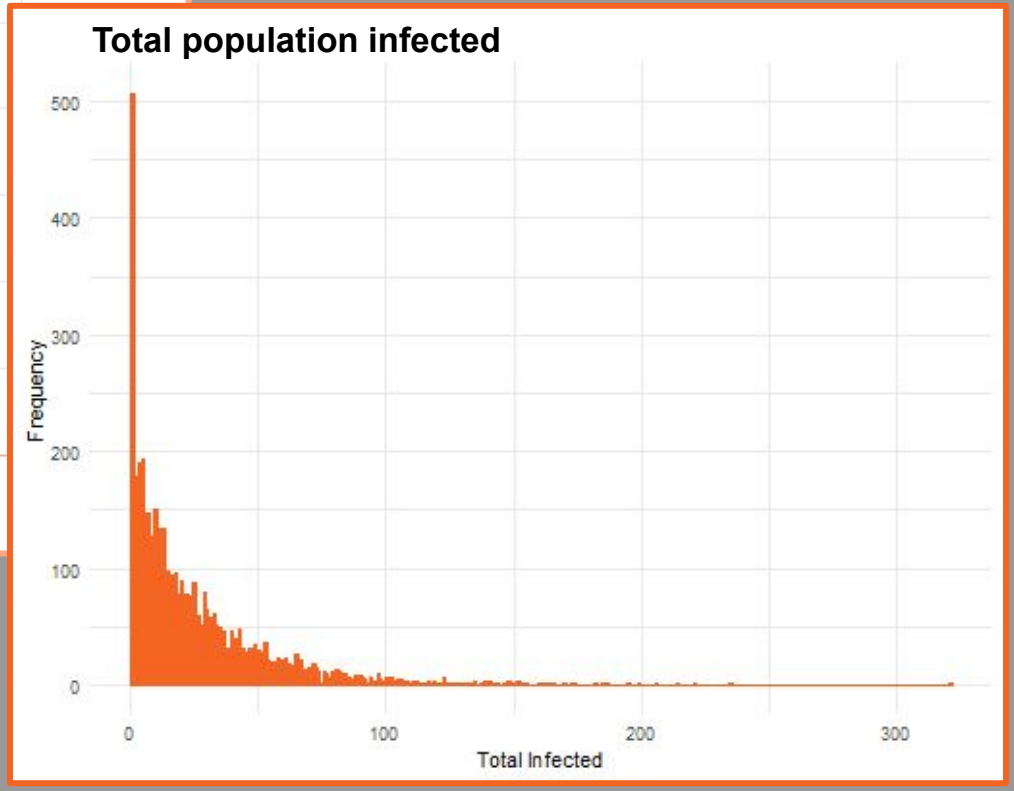
We sample 100 trees

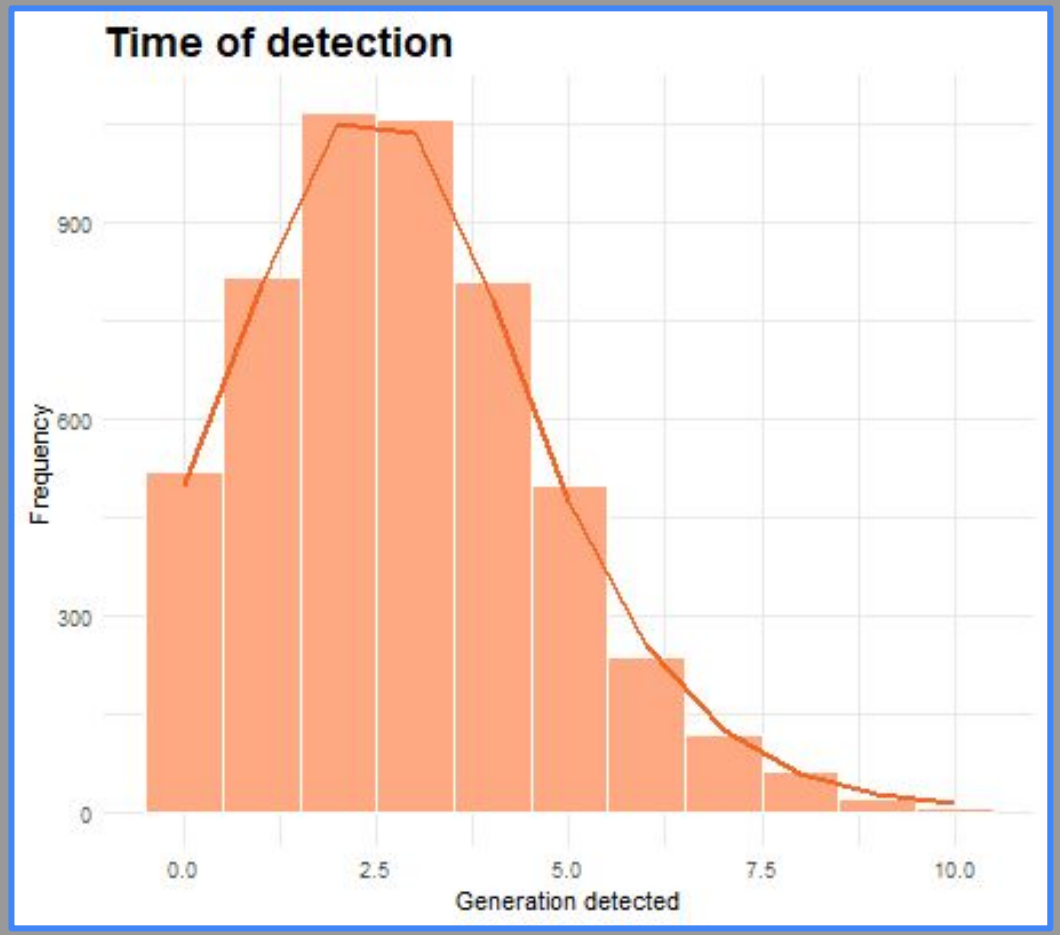
The detection probability is 0.05


Population
0
20
40
60
80
100
120
140
0
2
4
6
8
10
Time


Time/Population at detection
Population on detection
100
50
0
0
3
6
9
Time of detection
log(count)
100
10
1


Population on detection
600
400
200
0
Frequency
0
50
100
Population on detection


Total population infected
500
400
300
200
100
0
Frequency
0
100
200
300
Total Infected



The probability of being detected at generation *n* is:

$$g^n(0) - g^{n-1}(0)$$

Where $g^n(x)$ is the n^{th} iteration of the probability generating function of the offspring distribution

https://alicemh.shinyapps.io/hist/

Multitype model

Two types of node:

- Infectious nodes
- Non-infectious nodes

Infectious nodes:

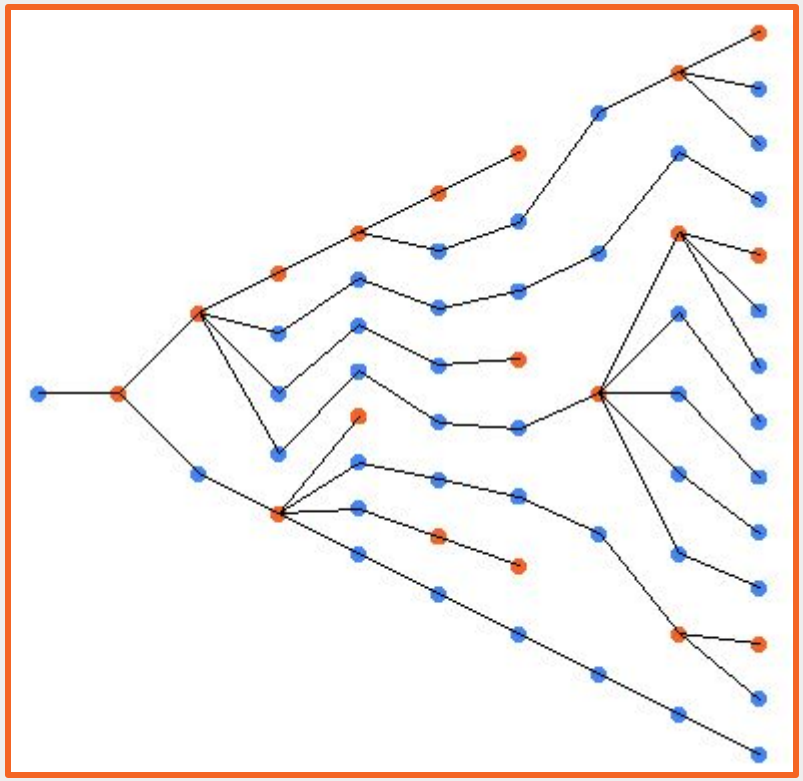
- Die with probability P
- Otherwise remain infectious and spread to a random number of non-infectious people

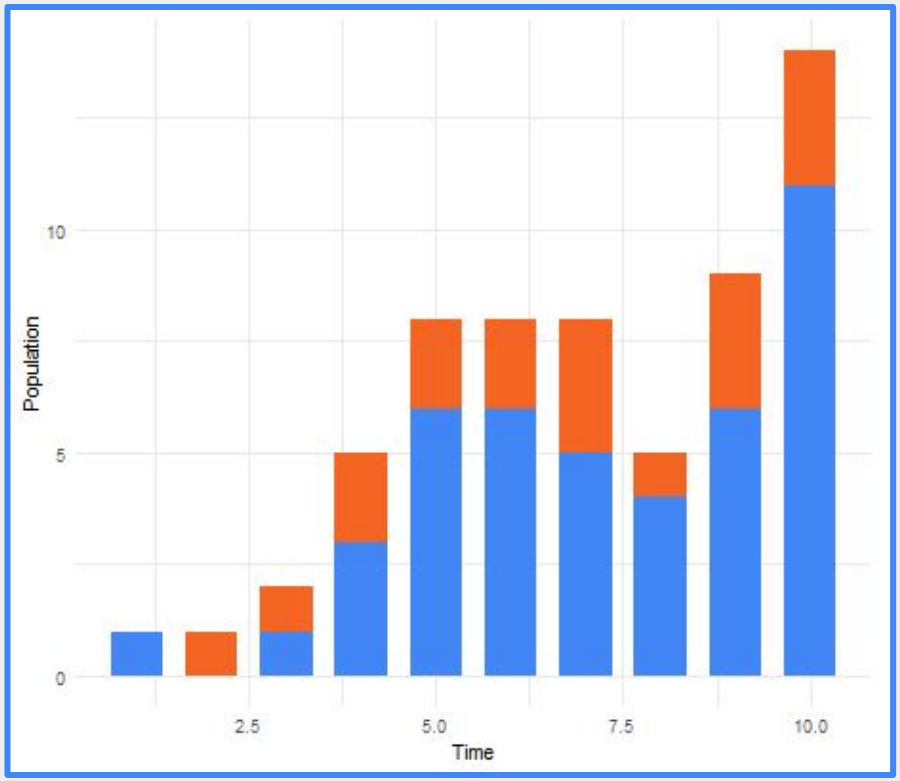
Non-infectious nodes:

- Turn infectious with probability Q
- Otherwise remain non-infectious

Orange nodes are infectious
Blue nodes are non-infectious

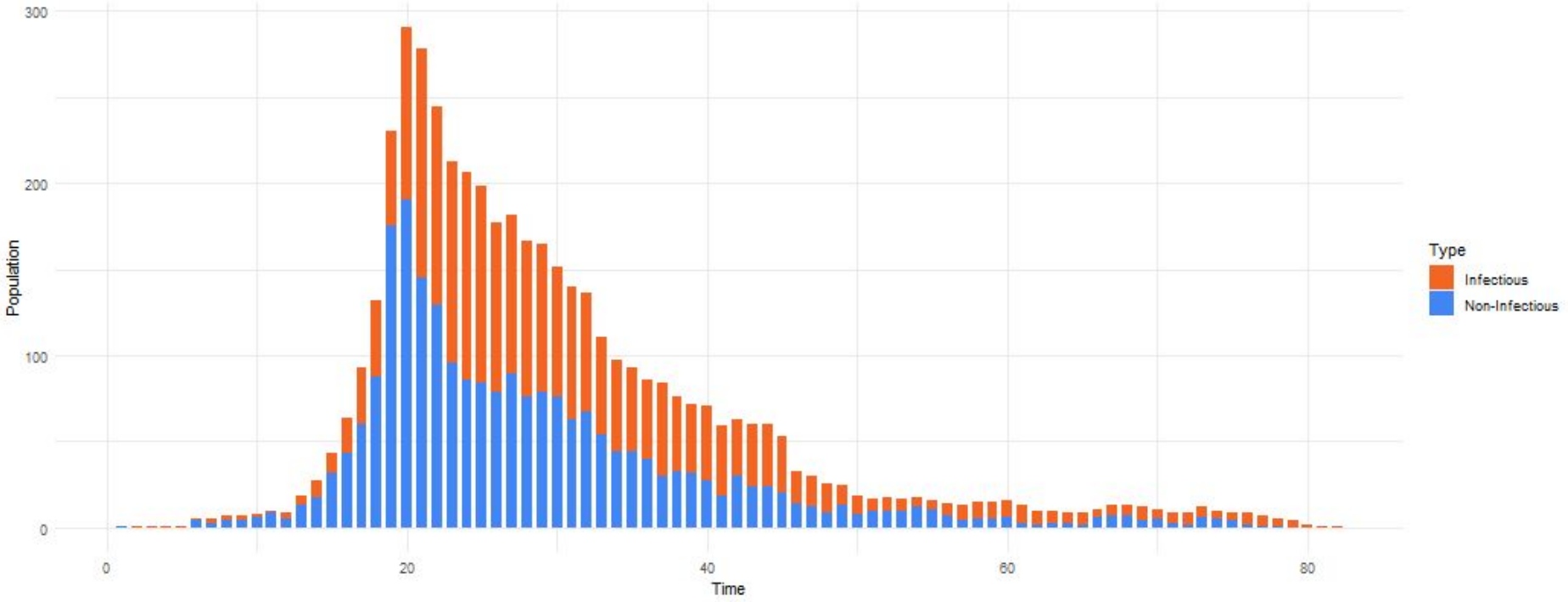
- On average, infectious nodes spread to 1.8 non-infectious nodes (geometrically distributed)
- The probability of infectious dying is 1/3
- The probability of non-infectious becoming infectious is 1/3



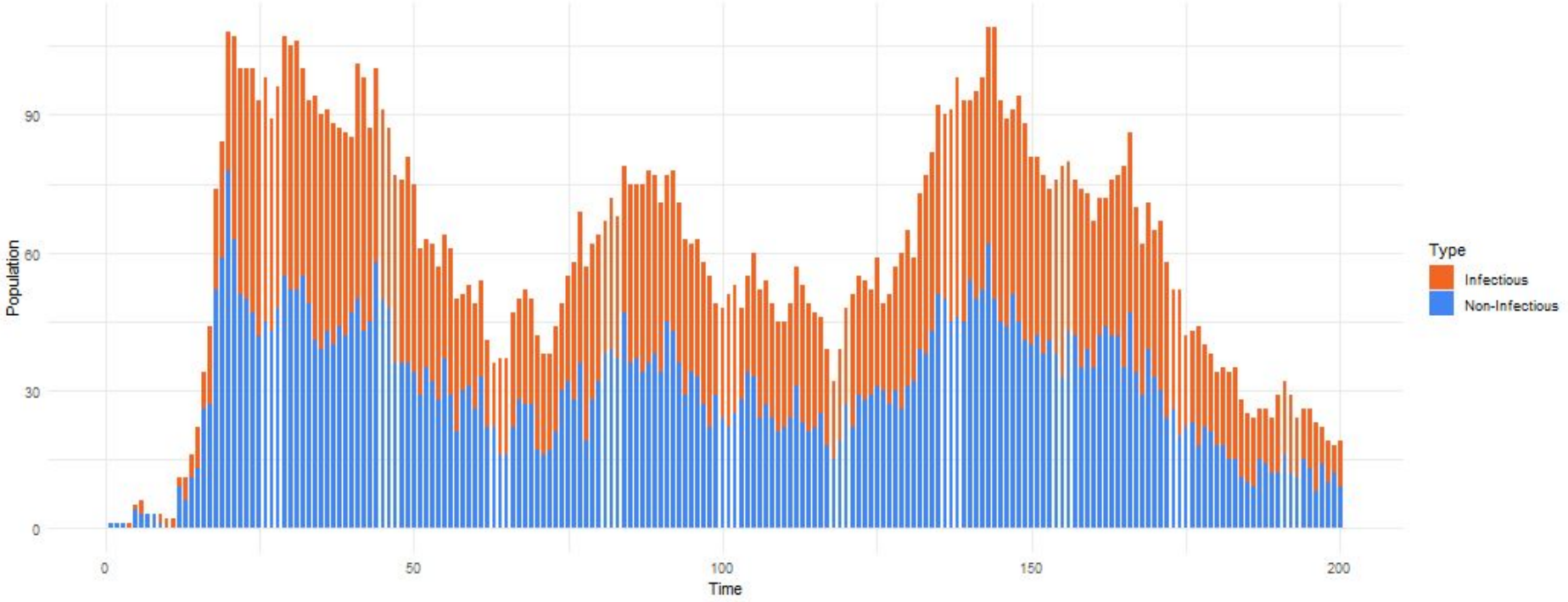


The average spread changes from 2.5 to 0.3 in generation 20

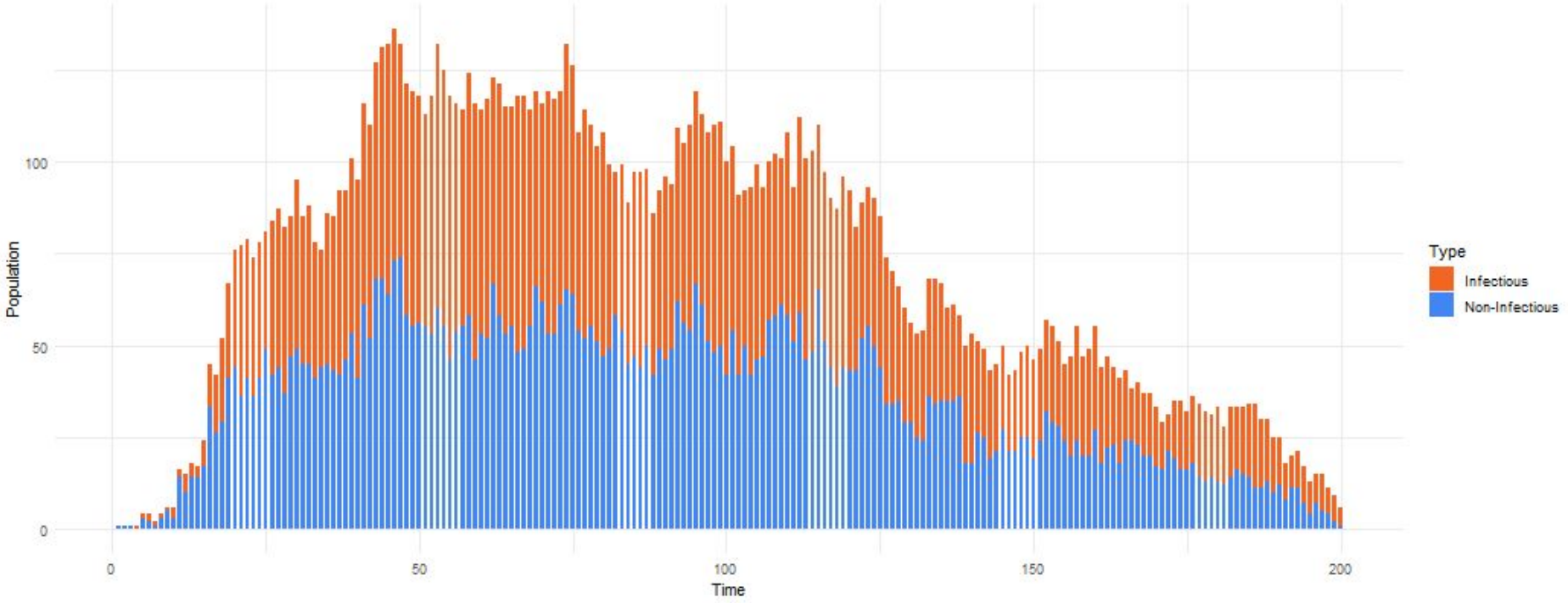
The probability of infectious dying and the probability of non-infectious becoming infectious remain at 1/3



The average spread changes from 1.8 to 0.5 in generation 20

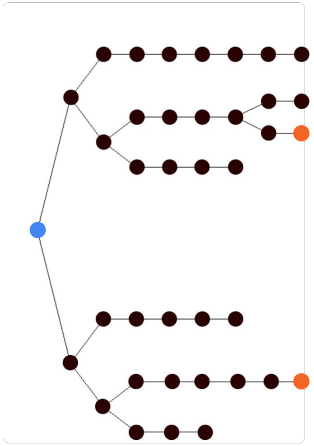


Average spread changes from 1.2 to 0.48 in generation 20

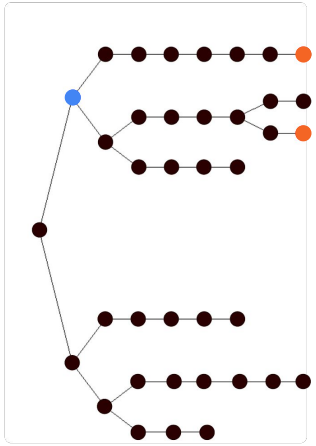


https://alicemh.shinyapps.io/multitype_2/

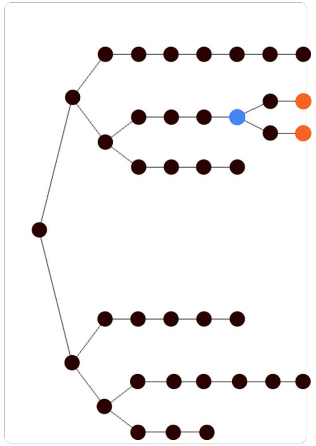
Most recent common ancestor of the orange points is in:



Generation 0

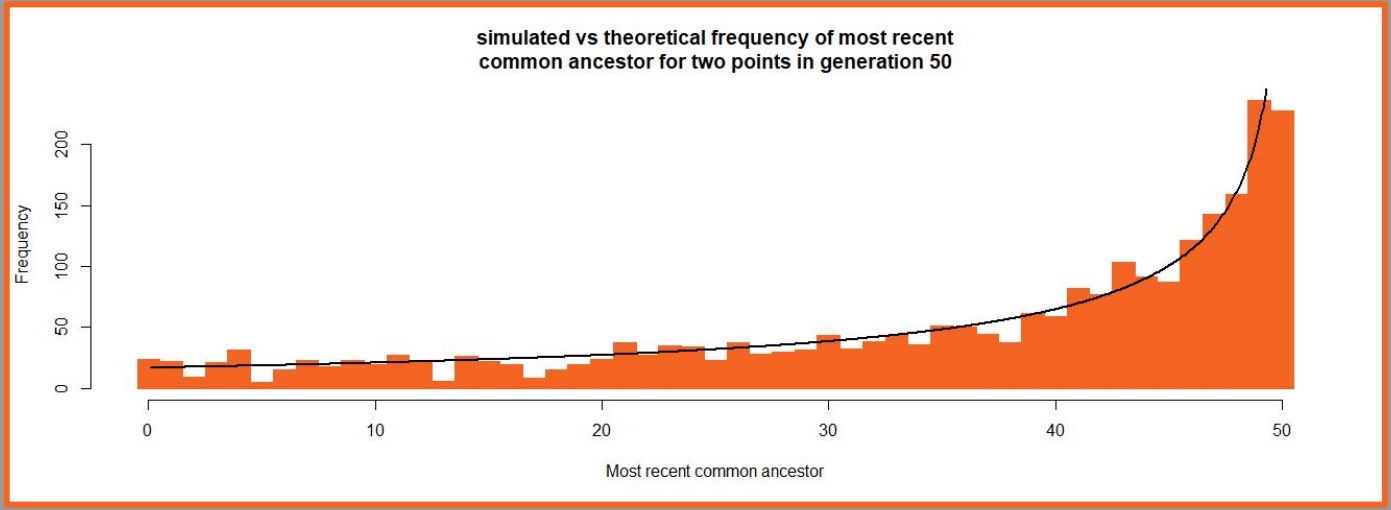


Generation 1



Generation 6

$$\frac{-4x - 2(x-2)\ln\left(\frac{1}{1-x}\right)}{x^3}$$

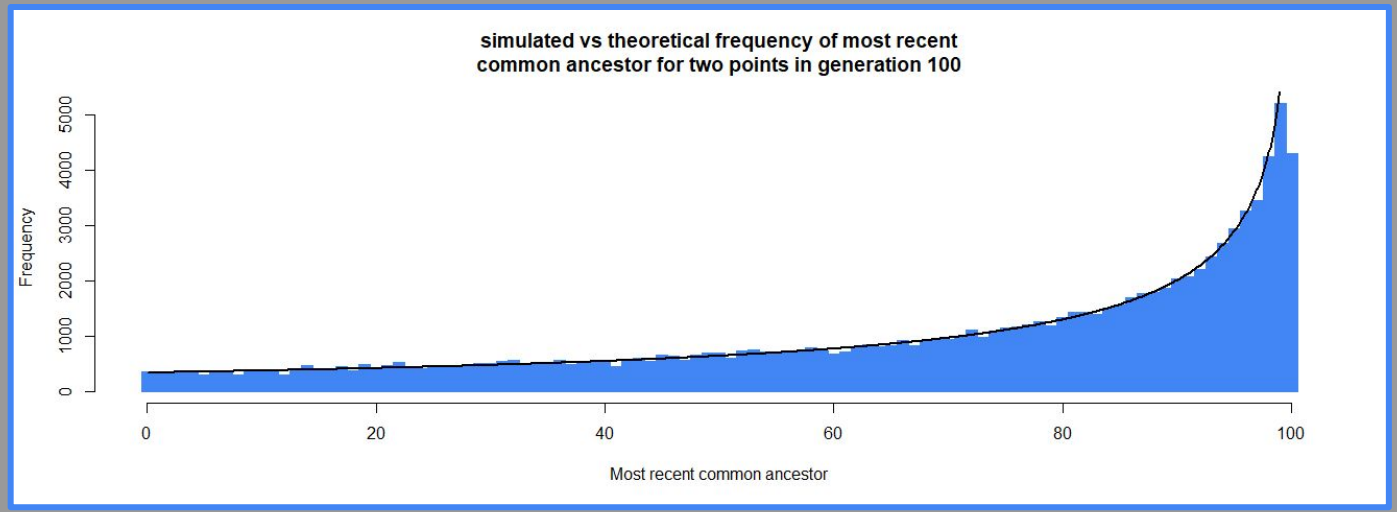


500 trees
5 samples per tree

Sampling at generation 50

10,000 trees
10 samples per tree

Sampling at generation 100



Thank you :)