Modeling Microevolutionary Processes

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Biological evolution is the change in the genetic structure of a population and/or species through time. This change is brought about by numerous forces acting upon individuals in a population. These forces include genetic drift, various modes of selection, non-random mating, and gene flow. Although these forces act to change gene frequencies, mutations are the raw source of variation.

Numerous mathematical models have been developed which simulate the genetic changes resulting from the action of the above evolutionary forces. The BioQUEST modules include a simulation program entitled Evolve which models the processes of drift, selection, and gene flow. Genetic drift is modeled through changes in the maximum population size and the post-crash population size. Selection is modeled through changes in survival rates and reproduction rates, and gene flow is modeled through changes in number of immigrants and percentage of emigrants. You set initial conditions for selection, drift, and gene flow, as well as the starting allele frequencies, starting population size, the number of generations you wish to model, and whether the population is in Hardy-Weinberg equilibrium. The starting point for each simulation is a random number. If you want to remove random effects (e.g., drift) from each simulation, then each time you run a simulation you must enter the same random number. If you wish to include random changes in each simulation, let the program choose the starting random number.

Today you will investigate the effects of some microevolutionary processes through use of the Evolve program.

Starting Evolve

1. Double-click the hard drive icon in the upper right corner of the screen to view a list of the folders (System, Documents, Applications). Open Applications.
2. Open the **BioQUEST** folder by double-clicking it.
3. Open the **Evolve** folder and double click the green **Evolve 2.041** icon.
4. A **BioQUEST** splash screen should appear. Click anywhere on the screen to move to the screen with the list of problems.
5. Two different Evolve manuals (EVOLVE Getting Started and EVOLVE Manual) are available in two formats (MS Word and Adobe Acrobat pdf). If you desire additional information, feel free to open these files.

Exercise 1. Effects of selection for an advantageous recessive allele that is initially uncommon in a large population.

1. Highlight **Selection for Recessive Allele** and click the **Start Problem** button.
2. A graph appears on your screen which resembles Figure 1:

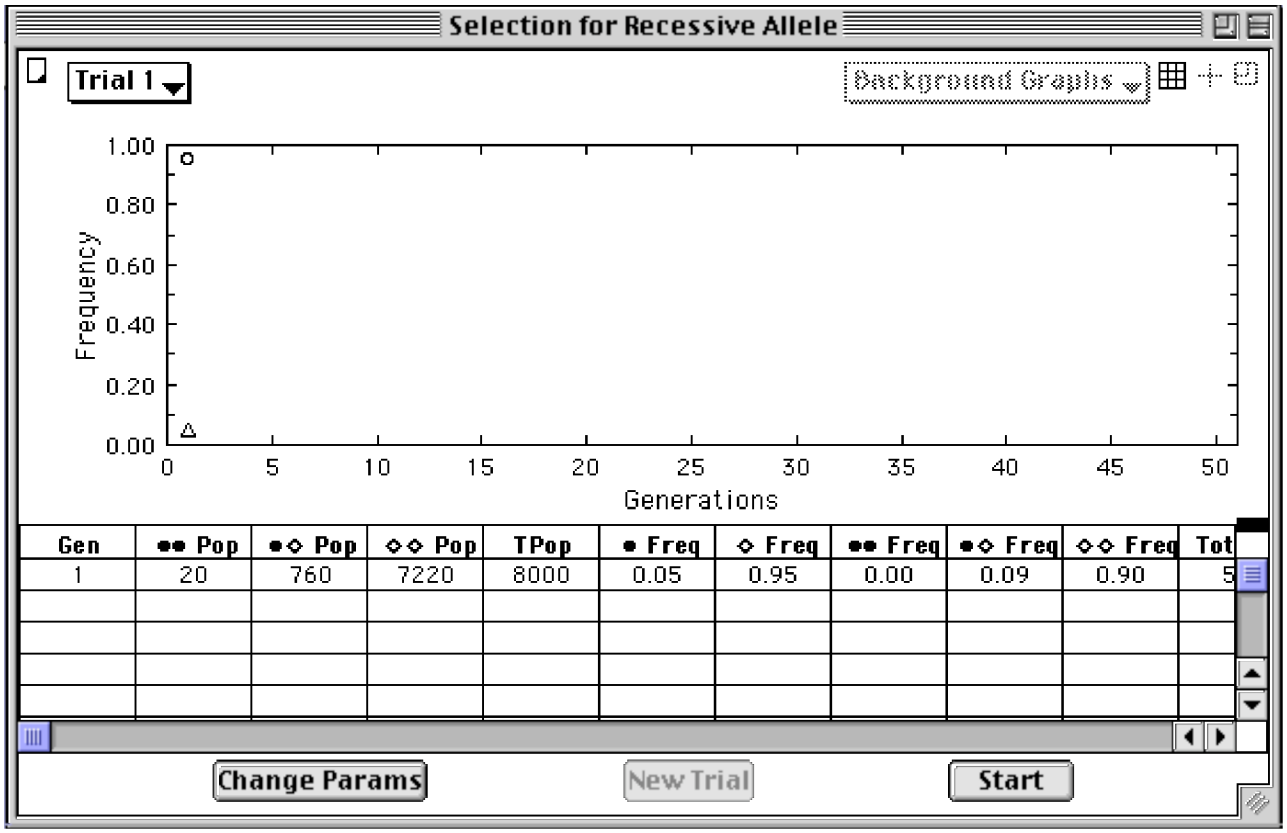

Figure 1. Starting screen for an Evolve simulation

3. Click the **Change Params** button to view the initial conditions for this simulation as displayed in Figure 2.

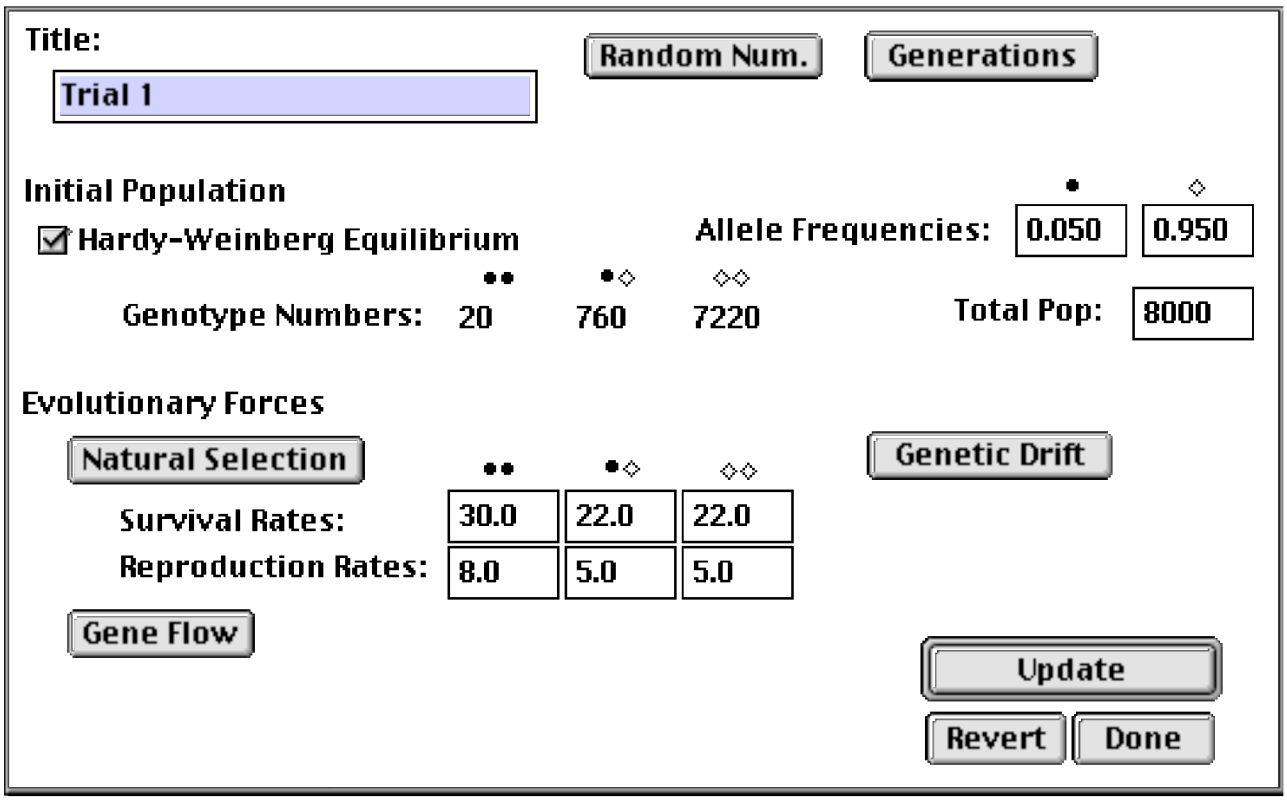

Figure 2. Change Params screen.

4. Record the **Allele Frequencies**, **Genotype Numbers**, **Total Pop**, **Survival rates** and **Reproduction Rates** for each genotype. Ignore the **Generations** (n=50), **Gene Flow**, and **Genetic Drift** buttons for now.
5. Type **Selection for Recessive** in the **Title** box.
6. Click the **Update** button.
7. Click the **Done** button to return to the blank graph.
8. Click on **Start** to begin the simulation.
9. You should see a figure that resembles Figure 3.

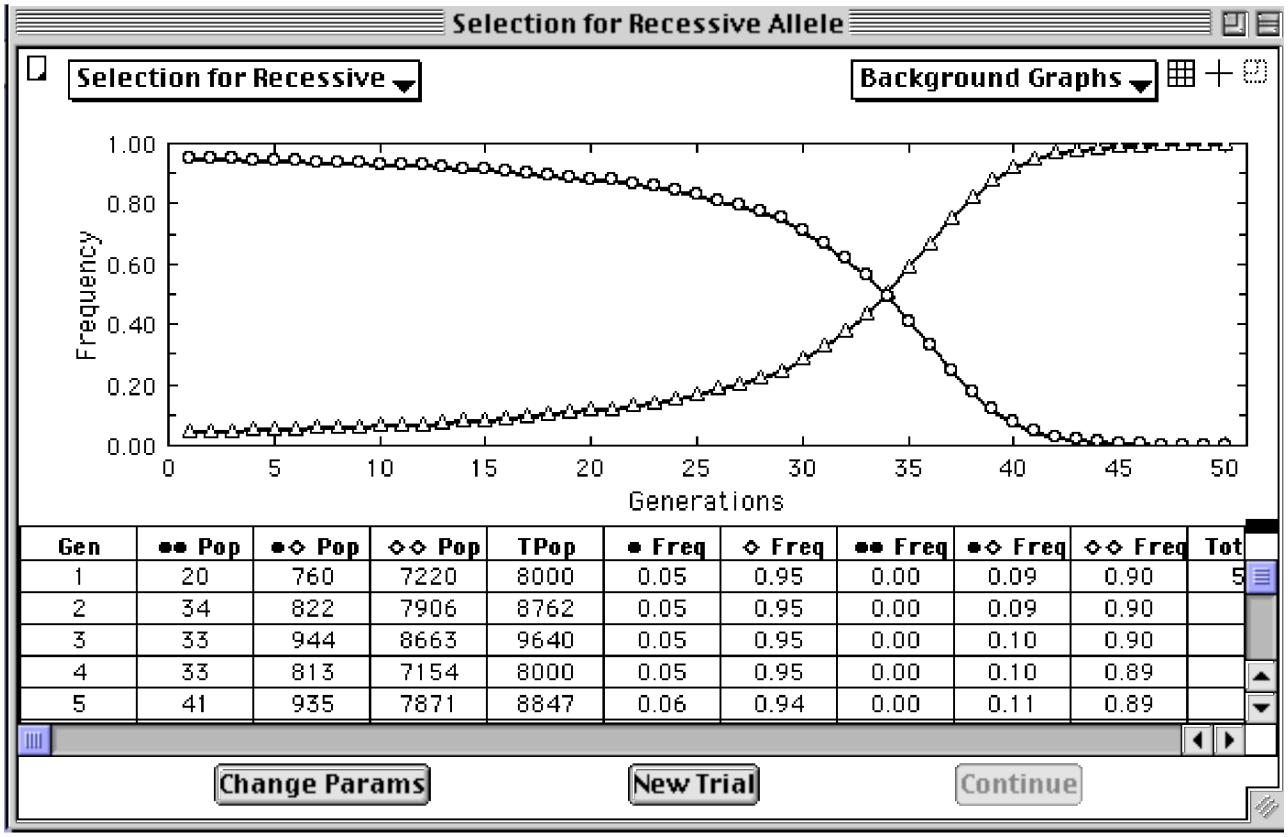

Figure 3. Selection for a recessive allele.

10. The two lines represent the allele frequencies.
    b. Go to the data table below the graph and hold the mouse button down while the cursor is over the dark circle allele to view the curve representing the change in frequency for that allele.
    b. Depress the mouse button over the open triangle allele to view the curve representing the change in frequency for that allele.
11. Open the **Graphs** menu at the top of the screen and deselect the **Allele Frequency** graphs by clicking on them (the check marks disappear when deselected) and select the three **Genotype Frequency** graphs to view changes in genotype frequencies. Choose the genotypes from the table to view the curves representing each genotype. The table below the graph displays the same data in numerical form. To see the entire table, enlarge the window until a scroll appears to the right of the table. This will allow you to scroll down the right-hand side of the table and see the changes over the generations. Make sure you record which graph lines correspond to the different genotypes or alleles. It is not necessary to print the entire table but you may want to record at which generations the frequencies change dramatically. For example, where they cross over or go close to zero or 100%.
12. Run a total of ten trials (remember to click the **New Trial** button for each additional trial) without changing any selection parameters. Note the influence of genetic drift in a large population under selection for a recessive allele.

13. To save the graph, first diminish the size of the screen by clicking the rectangle in the upper right hand corner. If the graph is too large, part of it will be lost when printing.
14. Then, click on **Edit** in the top menu and select **Copy Window Graph**. Now open up the **Notepad** and click on **Edit** and **Paste** to paste the graph in the **Notepad**. (The **Notepad** is opened by clicking in the small box in the upper left corner of the Evolve screen.) Alternatively, you can paste the graph into a word processing file (e.g., MS Word).
15. Type a figure legend (Figure 1. blah, blah, blah.) under the graph explaining what it represents. Include the title of the exercise. Do not extend the typed lines beyond the right edge of the graph because the words will not appear on the printed copy. Make sure describe what each line represents (e.g., open circles represent the recessive allele frequency and the open triangles represent the dominant allele frequency), the total population size, and the survival and reproductive rates for each genotype.
16. Print the **Notepad**.
17. Close the **Notepad**.

Exercise 2. Effects of selection on an advantageous recessive allele that is initially uncommon in a small population.

1. Go to the File menu at the top of the screen. Choose **New Problem**, click the **New** button, and select **Selection for Recessive Allele**.
2. Click **Change Parameters**.
3. Change the title of the exercise to Selection in a Small Population.
4. Leave the total population at 8000.
5. Click on the **Genetic Drift** box and change the maximum value to 100 and the post-crash population number to 80.
6. Select **Update** and then **Done**. When the graph appears select **Start**.
   The simulation will now run starting with a population of 8000, crash to a population of 80 and then run for the 50 generations. Note the changes in the genotype frequencies.
7. Run a total of ten trials.
8. Record any pertinent data from the table of generations and then save the graph as before.

Exercise 3. Effects of genetic drift in a large population with no advantageous alleles (no selection).

1. Go to the File menu at the top of the screen. Choose **New Problem**, click the **New** button, and select **Selection for Dominant Allele**.
2. Click **Change Parameters**.
3. Change the title of the exercise to Drift in a Large Population.
4. Change all **Survival** and **Reproduction Rates** to the same values.
5. Select **Update** and **Done**. When the graph appears select **Start**.
   The simulation will now run maintaining a population of around 8000.
6. Run ten trials.

7. Record any pertinent data from the table of generations and then save the graph as before.

Exercise 4. Effects of genetic drift in a small population with no advantageous alleles (no selection).

1. Go to the File menu at the top of the screen. Choose **New Problem**, click the **New** button, and select **Genetic Drift, Pop 80 - 100**.
2. Click **Change Parameters**.
3. Change the title of the exercise to Drift in a Small Population.
4. Record the **Total Pop, Maximum Pop, and Post-crash Pop.**
5. Run ten trials.
6. Record any pertinent data from the table of generations and then save the graph to the as before.

Exercise 5. Effects genetic drift in a very small population with no advantageous alleles (no selection).

Repeat exercise 4 using a maximum population of 15 and a post-crash population of 10. Remember to run 10 trials.

Discussion Topics

The discussion of your report should carefully analyze the effects these variables on the changes in genotype and allele frequencies.

1. For example, how do allele and genotype frequencies change over 50 generations when the recessive allele is advantageous (giving the recessive allele a selective advantage)?
2. Is the effect of selection different in a large population compared to a small population? How? Why?
3. What is likely to happen when the population crashes to a very small size? Why?
4. Are the effects of selection and drift similar in large and small populations? How? Why?
5. Are the effects of selection and drift different in large and small populations? How? Why?
6. These are examples of topics to think about. Try to think of others.