

Evolving to Invade

How can evolution by natural selection create invasive species?

Overview

Many invasive species do not start to invade as soon as they are introduced into a new area; there is a “lag time” in most invasions where scientists predict they are evolving to their new habitat and waiting for beneficial genes to arrive, either through mutation or further introductions of new individuals from their native range. Through an interactive game, students will learn how evolution might create an invasive species. The game demonstrates the basic components of evolution (variation and selection) and how they can cause an introduced species to become invasive and outcompete native species.

Objectives

At the conclusion of the lesson, students will be able to understand the basic concepts of evolution and biological invasions including:

- Evolution by natural selection
- Three factors required for evolution by natural selection to occur (variation in trait, fitness differences, inheritance)
- Source of variation (mutation, recombination and migration) and how these differ between native and invasive species
- The definition of an invasive species
- How evolution by natural selection can facilitate an invasive species

Length of Lesson

This lesson will take one class period (50-60 min)

- Background presentation (10 min)
- Playing game (30 min/game, *Note: Game can be played multiple times*)
- Plotting graph, interpretation of worksheet (10-20 min)

Grade Levels

Upper middle school and high school classes

Standards covered

L3.p4 Human Impact on Ecosystems (prerequisite)

All organisms cause changes in their environments. Some of these changes are detrimental, whereas others are beneficial. (prerequisite)

L3.p4A Recognize that, and describe how, human beings are part of Earth's ecosystems. Note that human activities can deliberately or inadvertently alter the equilibrium in ecosystems. (prerequisite)

B3.4 Changes in Ecosystems: Although the interrelationships and interdependence of organisms may generate biological communities in ecosystems that are stable for hundreds or thousands of years, ecosystems always change when climate changes or when one or more new species appear as a result of migration or local evolution. The impact of the human species has major consequences for other species.

B5.1 Theory of Evolution: The theory of evolution provides a scientific explanation for the history of life on Earth as depicted in the fossil record and in the similarities evident within the diversity of existing organisms.

B5.1A Summarize the major concepts of natural selection (differential survival and reproduction of chance inherited variants, depending on environmental conditions).

B5.1B Describe how natural selection provides a mechanism for evolution.

B5.1e Explain how natural selection leads to organisms that are well suited for the environment (differential survival and reproduction of chance inherited variants, depending upon environmental conditions).

B5.1g Illustrate how genetic variation is preserved or eliminated from a population through natural selection (evolution) resulting in biodiversity.

B5.3 Natural Selection: Evolution is the consequence of natural selection, the interactions of (1) the potential for a population to increase its numbers, (2) the genetic variability of offspring due to mutation and recombination of genes, (3) a finite supply of the resources required for life, and (4) the ensuing selection from environmental pressure of those organisms better able to survive and leave offspring.

B5.3A Explain how natural selection acts on individuals, but it is populations that evolve. Relate genetic mutations and genetic variety produced by sexual reproduction to diversity within a given population.

B4.3C Give examples of ways in which genetic variation and environmental factors are causes of evolution and the diversity of organisms.

B5.3d Explain how evolution through natural selection can result in changes in biodiversity.

Materials

- Student handout
- PowerPoint presentation
- Colored pencils
- ~2 hours of time to construct game materials
 - 60 ping pong balls
 - 1 yard (3 feet) of sticky-back Velcro
 - Scissors
 - 2 large bowls, two different colors
 - 1 smooth kitchen glove
 - 1 fuzzy winter glove

Background

Evolution is defined as a change in the average trait value of a population over time. Evolution by natural selection is the main mechanism driving a population to evolve. For that to occur, population needs to have a) variation among individuals in trait, b) consistent relationship between the trait and reproduction (fitness differences), and c) the trait has genetic basis and was inherited by parents. It is important to remember that evolution occurs on population level (a group of interbreeding individuals), not at individual or species level.

Organisms that introduced to a new habitat may evolve to adapt to a new habitat. If an introduced species out perform the native species and spread rapidly, they may become invasive, causing harm to the native ecosystem.

In this lesson, students have an opportunity to learn the basic concept of evolution and apply that knowledge to understand how introduced species may become invasive species. Below is a list of evolution vocabulary used throughout the lesson:

- Seed = **individual** = 1 ping-pong ball
- **Native range** seed predator = smooth kitchen glove
- **Invasive range** seed predator = fuzzy winter glove
- **population** = bowl full of ping-pong ball individuals
- **trait** = # Velcro pieces on a particular ping-pong ball (can also be called genotype or phenotype of the individual)
- **trait distribution** = the breakdown of trait values in the population. Represented with a graph where trait value is on the x-axis and # of individuals with that trait value is on the y-axis. Each individual represents a data point on the graph.
- **average trait** = average # of Velcro pieces/seed in the population
- **evolution** = change in the average trait value of a population over time
- **selection** = a consistent relationship between the trait value and survival of the seed. If seeds with lower trait values (less Velcro) always survive better, we would say there is selection for less Velcro.

Activities of the session

1. Go through intro PowerPoint presentation and introduce concepts of evolution by natural selection, and biological invasions. You may want to play this game only after you have thoroughly introduced one of these two topics in class, and use the game to add on a modification to that earlier lesson.
2. Before beginning game, make sure students understand the vocabulary words associated with evolution by natural selection (see above list). Introduce the parts of the game that represent each of the vocabulary words (descriptions above).
3. First, perform evolution in the native range where there is a lot of genetic variation present in the seeds (a full range of all the trait values represented).
 - a. Teacher fills the blue bowl with 2 seeds of each trait. Totals 12 seeds.
 - b. Have students draw a graph of the starting trait distribution. Calculate the average trait.
GRAPH 1A
 - c. Selection Round 1: one student, wearing the “native range predator” glove puts their hand into the bowl and takes a handful of seeds. Those seeds have been eaten by the seed predator and will not pass on their genes.
 - i. Make a second graph of the remaining seeds. Calculate the average trait after one round of selection. **GRAPH 1B**
 - ii. Each surviving seed produced one offspring – for every surviving seed, put in one more individual of that trait value.
 - d. Selection Round 2: repeat steps from Round 1 and graph the ending trait distribution.
GRAPH 1C
 - e. Selection Round 3: repeat steps from Round 1 and graph the ending trait distribution.
GRAPH 1D
 - f. Discuss with the class how the trait changed in the native range. Was there selection in one direction, or was it random?
4. Second, perform evolution in the invasive range where only a random small group of seeds from the native range is introduced at first.
 - a. Teacher fills the red bowl with a random handful of seeds from the native range, 5 seeds total. This represents a first random introduction of the invasive species to its invasive range.

- b. Have students draw a graph of what the starting trait distribution in the invasive range looks like. Calculate the average trait value. **GRAPH 2A**
- c. Selection Round 1: one student, wearing the “invasive range predator” glove puts their hand into the bowl and swirls it around to pick up a few seeds. Those seeds now stuck to the glove have been eaten by the seed predator and will not pass on their genes.
 - i. Make a second graph of the remaining seeds. Calculate the average trait value after one round of selection. **GRAPH 2B**
 - ii. Each surviving seed produced one offspring – for every surviving seed, put in one more individual of that trait value.
 - iii. Now, because we are in the invasive range there is a second introduction of the invasive species. Have a student grab 3 seeds from the native range blue bowl and add them to the invasive range blue bowl. Graph the new distribution. **GRAPH 2C**
- d. Selection Round 2: repeat steps from Round 1 as many times as you need to see a lag phase before the beneficial traits are introduced and take off in the invasive population.
 - i. Continue to graph how the trait distribution changes.
 - ii. Note how many rounds it takes a seed to come over that has a trait value of “0” or “1” (the most beneficial traits in the invasive range).
- e. Discuss the results of the game and the graphs. As a class, you have now demonstrated evolution. Make it clear to students that evolution resulted because the mean trait value changed over time. Questions for discussion:
 - i. Was there selection in the native range?
 - ii. What was selection for in the invasive range?
 - iii. How long did it take for a lot of genetic variation to be introduced in the invasive range?
 - iv. Would you have called the invasive species invasive right from the beginning of its introduction?

Resources

- Background information presentation (Evolving to Invade Powerpoint.pptx)
- Graphing sheet for students to plot the data (Student Worksheet.docx)
- See other GK-12 lessons and Data Nuggets on community ecology of invasive species:

Lesson Plans

- Invasive species game – how invasive species make it into the community
<http://kbsgk12project.kbs.msu.edu/blog/2012/03/19/invasive-species-game/>
- Biotic Resistance - what can stop invasive species?
<http://kbsgk12project.kbs.msu.edu/blog/2012/03/20/1500/>
- Invasion - Total Take-Over! Exploring invasive species and the methods to control them <http://kbsgk12project.kbs.msu.edu/blog/2012/03/20/invasion-total-take-over-exploring-invasive-species-and-the-methods-to-control-them/>
- Do herbivores prefer local or exotic foods?
<http://kbsgk12project.kbs.msu.edu/blog/2012/03/19/do-herbivores-prefer-local-or-exotic-foods/>

Data Nuggets

- Do invasive species escape their enemies?
<http://kbsgk12project.kbs.msu.edu/blog/2011/08/05/do-invasive-species-escape-their-enemies/>
- Do insects prefer local or foreign foods?
<http://kbsgk12project.kbs.msu.edu/blog/2011/12/14/do-insects-prefer-local-or-foreign-foods/>

Extensions and Modifications

This activity can be adapted from evolution in an invasive species, to evolution in any type of species that might be discussed during class.

Assessment

Students will be assessed with participation in discussion and graphing and data interpretation.