

ISLAND BIOGEOGRAPHY LAB¹

I do not deny that there are many and grave difficulties in understanding how several of the inhabitants of the more remote islands, whether still retaining the same specific form or modified since their arrival, could have reached their present homes.

-C.R. Darwin, On the Origin of Species, 1859.

Laboratory Goals

Understand the processes underlying the theory of island biogeography. Conduct a simulation of these processes and analyze the data resulting from the simulation.

Laboratory Objectives

1. Identify key variables determining the number of species on an “island.”
2. Qualitatively explain how key variables determine the number of species on an “island.”
3. Conduct a simulation that focuses on the key variables that determines the number of species on an “island.”
4. Demonstrate graphically using data from the simulation how key variables determine the number of species on an “island” and the equilibrium species richness.
5. Compare the results from the simulations with theoretical predictions.

Materials

Each group of 6-7 students will need the following:

1. A countdown timer or stopwatch (a watch with a second-hand will do) to time the “colonization” bouts.
2. PVC squares to simulate square islands.
3. One container of labeled wood disks (15 “species”, and a minimum of 7 individuals per species). Letters (A-O) indicate species. This is the mainland or “source” population.
4. A clipboard with four data sheets (1 data sheet for each simulation). Additional data sheets will be provided.
5. A meter stick to measure island distances.

***All materials provided except stopwatch.**

¹ Heavily modified from Haefner, J.W., Rowan, D.E., Evans, E.W. and Lindahl, A.M. Island biogeography: students colonize islands to test hypotheses. Association for Biology Laboratory Education (<http://www.zoo.utoronto.ca/able>).

Experimental Protocol

1. There will be four island configurations (Small and large islands, and near and far islands). However, there will likely be only enough time for only each group to complete two simulations. Half the class will simulate small islands, and half large islands.
Small island (0.25 m²)
 Close (2 m)
 Far (4 m)
Large island (1 m²)
 Close (2 m)
 Far (4 m)
2. With the meter stick, string, and stakes or tape, locate your island anywhere safe on the playing field. For example, you do not want your flight path intersecting with another group's flight path.
3. Establish your source population (i.e., the container with all the wood disks). To do this, measure your group's island distance from the center of your island in any safe direction. Plant a flag or stake at this location. This is where you will be dispersing your species. Sit or kneel with the container containing your source population (the one with all the wood disks) at this spot.

Division of Labor

Each group consists of 6 or 7 students. The following jobs need to be distributed among group members for each simulation-switch up jobs after the first simulation.

1. **Thrower:** This person should be your most precise and unbiased thrower (i.e., consistently accurate). Practice to determine this. The thrower tosses as many plastic disks from the source population box, while sitting or kneeling, as he or she can in 15 seconds. The thrower may not throw the next disk until the previously thrown disk has hit the ground. You may find it convenient to put the "immigrating" species in a pile in front of you.
2. **Timer:** The timer keeps track of the three replicates of 20, 15-second colonization events. The timer shouts start and stop to disk thrower at the beginning and end of a colonization event.
3. **Scorer:** The scorer examines the island and calls out to Recorder the identity of the resident species (R) after each 15-second colonization event.
4. **Shuttler:** The shuttler returns unsuccessful colonists (disks outside the island) to the mainland area after each 15 second round. Be sure to mix the source population disks after each round to maintain an approximately random distribution.
- 5-6. **Recorders:** This person records on the data sheets the species present after a throwing bout as determined by the scorer. Furthermore, he or she keeps track of immigration (I) and extinction (E) events. All information is tallied on the data sheets provided (one sheet per replicate experiment of 20, 15 second bouts). A second person can act as a back-up or helper recorder.

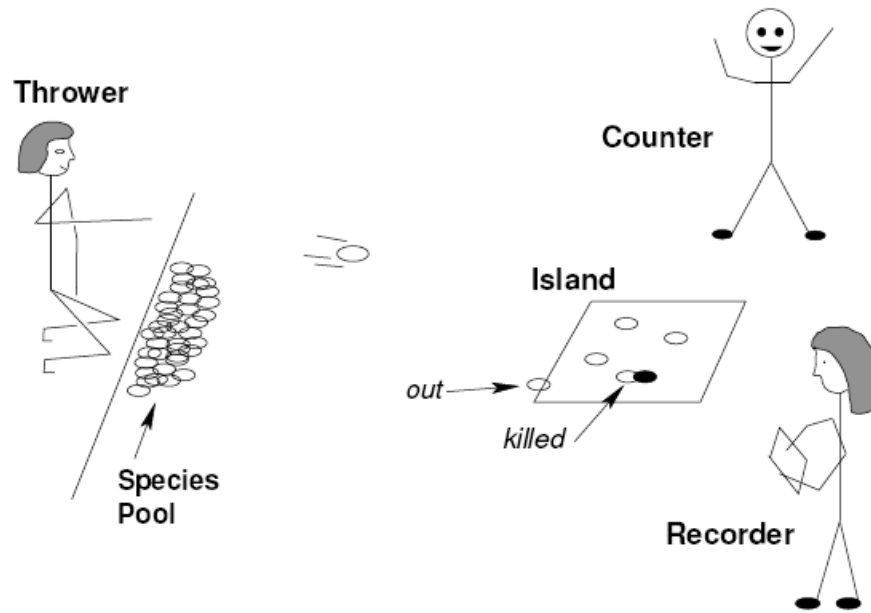


Figure 1 depicts the general layout of the exercise.

Scoring Definitions and Rules

After a colonization bout, or at the end of the lab, the number of immigrants and extinctions are tallied. See the example below that illustrates how to score immigrations and extinctions.

1. **Immigrant (I):** An immigration event is the arrival on the island of an individual (disk), which was not present in the prior colonization bout. At least one-half of the disk must be inside the boundary to count as a successful individual.
2. **Extinctions (E) and Individual Deaths:** An individual dies and is removed from the island if another individual lands on top of it. A species goes extinct when the last individual in its species is removed from the island. If this happens, there will be no "X" in its column on the data sheet and it will be recorded as an extinction event. Remove the dead individual by sliding it from under the new species and return it to the mainland. If a newly immigrating individual lands on one of two or more individuals on the island, both are killed and removed from the island. All disks coming to rest outside the island boundaries or more than halfway outside the island boundaries following a 15 sec colonization attempt are considered "dead" and recycled.
3. **Number of Resident Species:** The number of resident species (R) is the number of each species remaining on the island after a 15 second colonization event after taking into consideration any extinctions or new immigrations that took place.

Note: Consult with your instructor if you have any questions about scoring. It is important that all groups are consistent.

Important Tips

Your data will be best if you remember to do the following.

1. Take care with throwing. Throw as accurately but as quickly as you can in each 15-second bout.
2. After **each** bout, return all of the disks that are **outside** the island back to the Thrower.

Only remove the individuals that died from within the island.

3. Randomize your source pool of species. Before each throwing bout, mix up the species pool of disks.

Tallying Data

After determining the number of immigrants and extinctions that occurred during the 15 sec bout, the scorekeeper records (with check marks) the number of resident species present after each colonization event (see worked example below). Species are listed across the top, and time (colonizing bout) along the side. **Remember:** Only presence or absence of species is important; we do not need to record numbers of individuals. This tallying may be done at the end of the lab, and should be double-checked by other group members.

Table 1. Sample calculation of R, E, and I. An “X” indicates the species was present after the throwing bout (t). An immigration occurs when an “X” appears; an extinction occurs when an “X” disappears. R=number of resident species, I=number of new species immigrating (also the immigration rate), E=number of species going extinct (also the extinction rate).

Bout	Species				Variables		
	A	B	C	D	R	I	E
0	—	—	—	—	0	1	0
1		X			1	2	0
2	X	X	X		3	1	1
3	X	X		X	3	—	—

From bout = 0 to bout = 1, your island had 1 immigrant (species B) and, of course, no extinctions. So, a 1 is recorded in the I column at bout = 0, and the immigrating species B is checked (X) in the bout = 1 row. Therefore, the number of residents after the first colonization bout is 1 ($1 = 0 + 1 - 0$).

From bout = 1 to bout = 2, your island had 2 immigrants (species A and C) and no extinctions. So, a 2 is recorded in the I column at bout = 1 and a 0 in the E column at bout = 1. The species immigrating are checked in the bout = 2 row by placing an ‘X’ in columns A and C. Therefore, the number of residents after the second bout is 3 ($3 = 1 + 2 - 0$).

From bout = 2 to bout = 3, your island had 1 immigrant (species D) and 1 extinction (species C). So, a 1 is recorded in the I and E columns at bout = 2, and the species are checked in the bout = 3 row. Therefore, the number of residents after 3 bouts is 3 ($3 = 3 + 1 - 1$). This process is continued until 20 15-second colonization bouts have been completed.

Pool the Data

When your group has completed the simulations, share your data among group members on I, E and R. Also, obtain data from a neighboring group that was simulating a different island size.

If time permits, complete all four simulations. It is optimal if the thrower remains the same person throughout all four simulations.

Species-Area Curve

To estimate the parameters of the species-area curve, we need more than two areas. Some of the groups, as assigned by the instructor, will also simulate colonization at five island sizes (at 2-meter distance). The activities are exactly as before, **except** you do not need to record numerically immigrations and extinctions. Here, we are interested only in the equilibrium number of species. So, after each colonizing bout, kill the individuals that overlap, return the outside plates to the thrower, and record the number of species on the island. Repeat until the numbers of species is approximately constant over three bouts. Record the number of species after each bout.

Islands for this exercise will be constructed from string wrapped around four stakes.

Use these dimensions:

Edge length (m)	Island area (m ²)
0.5	0.25
0.71	0.5
1	1.0
1.22	1.5
1.41	2.0

*The data from this group will be shared among all other groups.

Island size:

Distance to mainland:

Species



t	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	R	I	E
0																		
1																		
2																		
3																		
4																		
5																		
6																		
7																		
8																		
9																		
10																		
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		

Species/Area Curve Data Sheet

Trial 1

Data are number of resident species after each bout
Island Size (m²)

Bout (t)	0.25	0.5	1	1.5	2
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					

ISLAND BIOGEOGRAPHY: SUMMARY DATA SHEETS FOR SHARING DATA.

Island Area: Distance:				Island Area: Distance:				Island Area: Distance:			
Bout #	R	I	E	Bout #	R	I	E	Bout #	R	I	E
1				1				1			
2				2				2			
3				3				3			
4				4				4			
5				5				5			
6				6				6			
7				7				7			
8				8				8			
9				9				9			
10				10				10			
11				11				11			
12				12				12			
13				13				13			
14				14				14			
15				15				15			
16				16				16			
17				17				17			
18				18				18			
19				19				19			
20				20				20			

Island Area: Distance:				Island Area: Distance:				Island Area: Distance:			
Bout #	R	I	E	Bout #	R	I	E	Bout #	R	I	E
1				1				1			
2				2				2			
3				3				3			
4				4				4			
5				5				5			
6				6				6			
7				7				7			
8				8				8			
9				9				9			
10				10				10			
11				11				11			
12				12				12			
13				13				13			
14				14				14			
15				15				15			
16				16				16			
17				17				17			
18				18				18			
19				19				19			
20				20				20			