

Answers to Exercise 9

Interspecific Competition and Competitive Exclusion

1. Try plugging the following values into your spreadsheet model:

- $R_1 = 0.25$, $K_1 = 3000$, $\alpha_{12} = 1.25$
- $R_2 = 0.50$, $K_2 = 1000$, $\alpha_{21} = 0.50$
- $N_{1,0} = 50$, $N_{2,0} = 100$

Species 1 will go to K_1 , excluding species 2, which will go to zero. This happens despite the fact that we have given species 2 a faster population growth rate, higher initial population size, and greater competitive ability ($\alpha_{12} > \alpha_{21}$). You might think species 1 wins because of its larger K , but this is not quite correct, as you will see in answering the next question.

Meanwhile, experiment with different values of R and N_0 for both species. You should find that the outcome is the same (species 1 excludes species 2), regardless of the values you put in for R 's and N_0 's. Apparent exceptions may arise if you put in very large values, which may cause one or both populations to go negative, which makes no biological sense. Large values of R may produce oscillations or chaos.

In ecological terms, species 1 excludes species 2 because its population can continue to grow even when species 2 is present at its own carrying capacity.

2. Try the following values:

- $R_1 = 0.25$, $K_1 = 3000$, $\alpha_{12} = 2.25$
- $R_2 = 0.25$, $K_2 = 2000$, $\alpha_{21} = 0.25$
- $N_{1,0} = 50$, $N_{2,0} = 50$

Species 2 will go to K_2 , excluding species 1, which will go to zero despite the fact that $K_1 > K_2$.

In ecological terms, species 2 excludes species 1 because its population can continue to grow even when species 1 is present at its own carrying capacity. As before, experiment with different values of N_0 and R for both species. You should find that they will not change the outcome, but confirm this for yourself.

3. Try the following values:

- $R_1 = 0.75$, $K_1 = 2500$, $\alpha_{12} = 0.75$
- $R_2 = 0.50$, $K_2 = 2000$, $\alpha_{21} = 0.50$
- $N_{1,0} = 50$, $N_{2,0} = 50$

The two populations will come to equilibrium at $N_1 = 1600$ and $N_2 = 1200$. Is this equilibrium stable?

Try the following values of N_0 :

- $N_{1,0} = 1000, N_{2,0} = 1$
- $N_{1,0} = 1, N_{2,0} = 1000$
- $N_{1,0} = 500, N_{2,0} = 2500$
- $N_{1,0} = 1000, N_{2,0} = 3000$
- $N_{1,0} = 250, N_{2,0} = 3000$.

You should see that the two populations return to the same equilibrium point, regardless of initial population sizes. This demonstrates that this is a stable equilibrium. If the two populations are at equilibrium, and are disturbed in any direction, they return toward the same equilibrium values.

You can also vary R values, and should find that this does not affect the outcome.

Parameter values that meet the conditions given above represent situations in which each species limits its own population growth more than it limits growth of the other population. In other words, intraspecific competition is more intense than interspecific competition.

This result has led to a major generalization of ecological theory: the **competitive exclusion principle**. This principle states that two species cannot coexist unless their niches are sufficiently different that each limits its own growth more than it limits that of the other.

4. Try the following values:

- $R_1 = 0.50, K_1 = 1000, \alpha_{12} = 1.25$
- $R_2 = 0.50, K_2 = 1000, \alpha_{21} = 1.25$
- $N_{1,0} = 50, N_{2,0} = 50$

The two populations will come to equilibrium at $N_1 = 444$ and $N_2 = 444$. Is this equilibrium stable?

Try the following values of N_0 :

- $N_{1,0} = 100, N_{2,0} = 50$
- $N_{1,0} = 50, N_{2,0} = 100$
- $N_{1,0} = 500, N_{2,0} = 444$
- $N_{1,0} = 444, N_{2,0} = 500$.

Whichever population starts out larger will exclude the other. Also try values closer to the equilibrium, such as:

- $N_{1,0} = 445, N_{2,0} = 444$
- $N_{1,0} = 444, N_{2,0} = 445$.

You should see that the equilibrium is unstable, because, even starting very close to equilibrium, the populations diverge from equilibrium, rather than returning toward it.

If the populations happened to be at equilibrium, the slightest disturbance would send them flying away from it.

You can also try different values of R . If the two populations begin at the same size, the one with the larger R will exclude the other.

In ecological terms, such parameter values correspond to a situation in which each species affects the other more than it affects itself. In other words, interspecific competition is more intense than intraspecific competition.