lab04_bazari

2025-03-05

Exercise 1

1. Stable coexistence

(i) Stable coexistence occurs when:

$$K1/\alpha_{12} > K2$$

and

$$K2/\alpha_{21} > K1$$

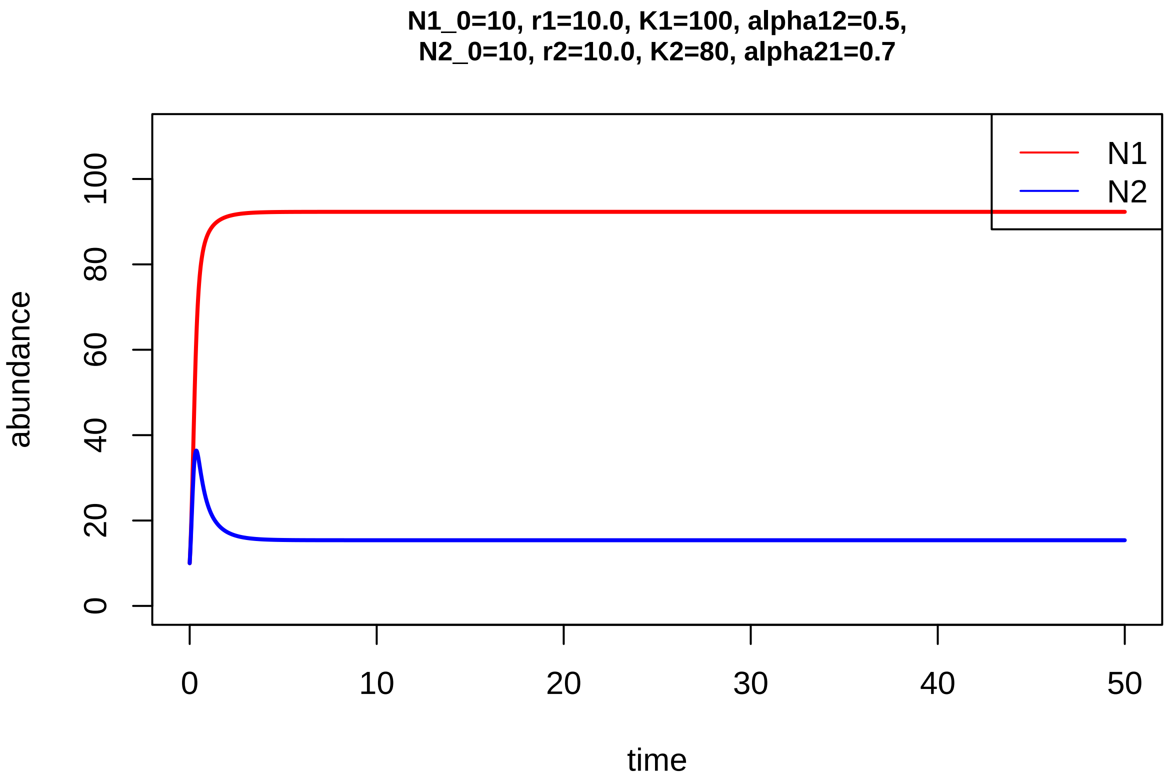
$$K1/\alpha_{12} = 200 > K2 = 80$$

$$K2/\alpha_{21} = 114 > K1 = 100$$

(ii) Each species limits itself more than it limits the other species. So, intraspecific competition > interspecific competition. Intra-specific competition dominates. Both species can stably coexist because they do not drive eachother to extinction. Species 1 can tolerate some Species 2 and vice versa. Shows mutual tolerance and stable equilibrium where both survive.

(iii) Example Parameters:

```
lvCompetition(N1_0=10, r1=10, N2_0=10, r2=10,
                         K1=100, K2=80, alpha12=0.5, alpha21=0.7, endTime=50)
```



- Both species stabilize at non-zero abundance. Species 1 (red) is more dominant, but Species 2 (blue) persists as well. The quick meeting to equilibrium shows strong regulation of population densities.

2. Unstable coexistence

(i) Unstable coexistence occurs when:

$$K1/\alpha_{12} < K2$$

and

$$K2/\alpha_{21} < K1$$

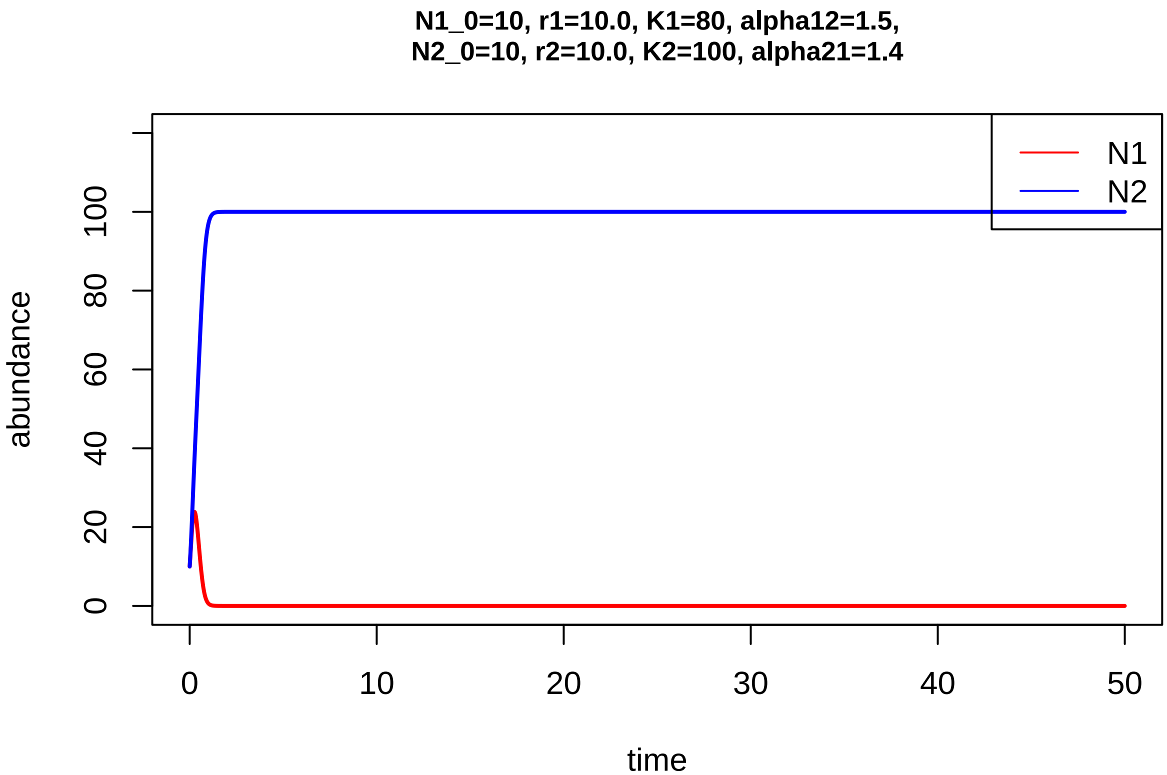
$$K1/\alpha_{12} = 53.3 < K2 = 100$$

$$K2/\alpha_{21} = 71.4 < K1 = 80$$

(ii) Interspecific competition effect is greater than the intraspecific effect. Each species harms the other more than it harms itself. Coexistence is possible only under specific and ideal initial conditions. Any imbalance in this system would lead to exclusion due to the sensitivities.

(iii) Example Parameters

```
lvCompetition(N1_0=10, r1=10, N2_0=10, r2=10,
                    K1=80, K2=100, alpha12=1.5, alpha21=1.4, endTime=50)
```



- Species 2 (blue) wins and excludes Species 1 (red). This outcome could potentially flip if the initial conditions are reversed.

3. Species 1 wins / Species 2 goes extinct

(i) Species 1 outcompetes Species 2

$$K1/\alpha_{12} > K2$$

and

$$K2/\alpha_{21} < K1$$

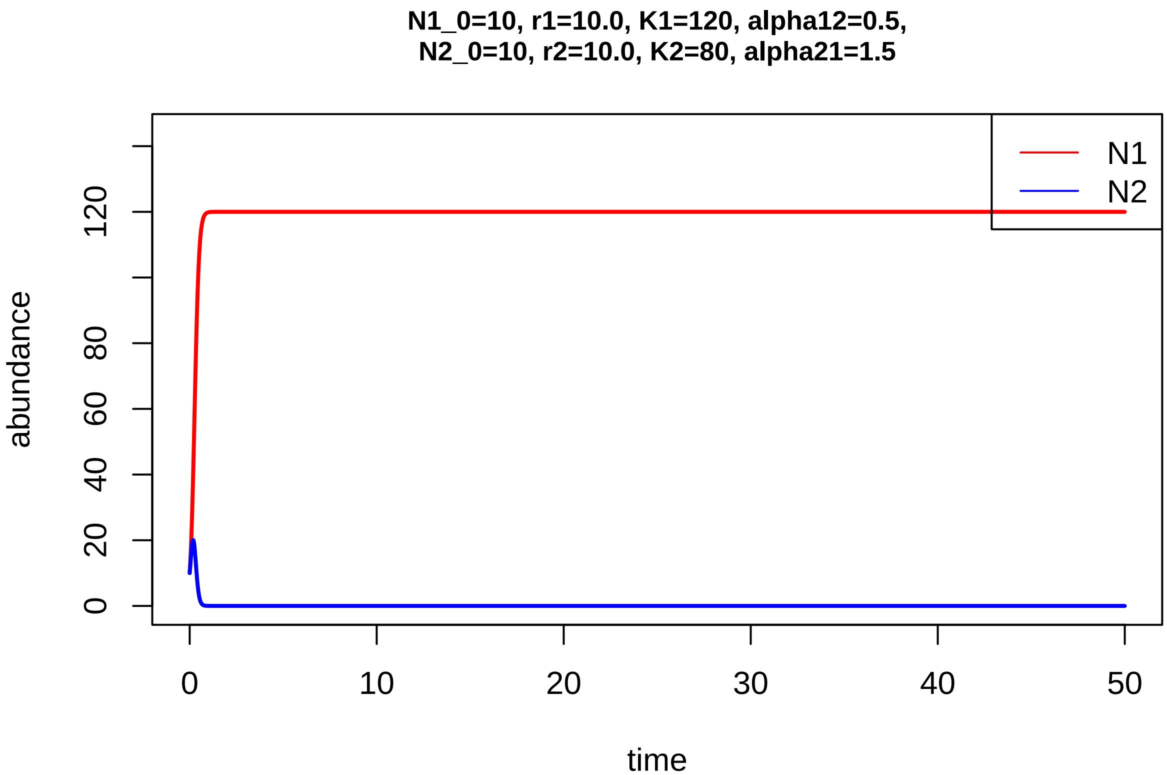
$$K1/\alpha_{12} = 240 > K2 = 80$$

$$K2/\alpha_{21} = 53.3 < K1 = 120$$

(ii) Species 1 is the superior competitor. Species 1 has a high tolerance to competition and Species 2 suffers from Species 1. Species 1's intra-specific competition is weaker than its advantage over Species 2. Species 1 will outcompete and excluse Species 2 over time.

(iii) Example Parameter

```
lvCompetition(N1_0=10, r1=10, N2_0=10, r2=10,
                          K1=120, K2=80, alpha12=0.5, alpha21=1.5, endTime=50)
```



- Species 1 (red) quickly reaches its carrying capacity. Species 2 (declines) to zero as its being excluded. This is the reverse of the previous condition.

4. Species 2 wins / Species 1 goes extinct

(i) Species 2 outcompetes Species 1

$$K1/\alpha_{12} < K2$$

and

$$K2/\alpha_{21} > K1$$

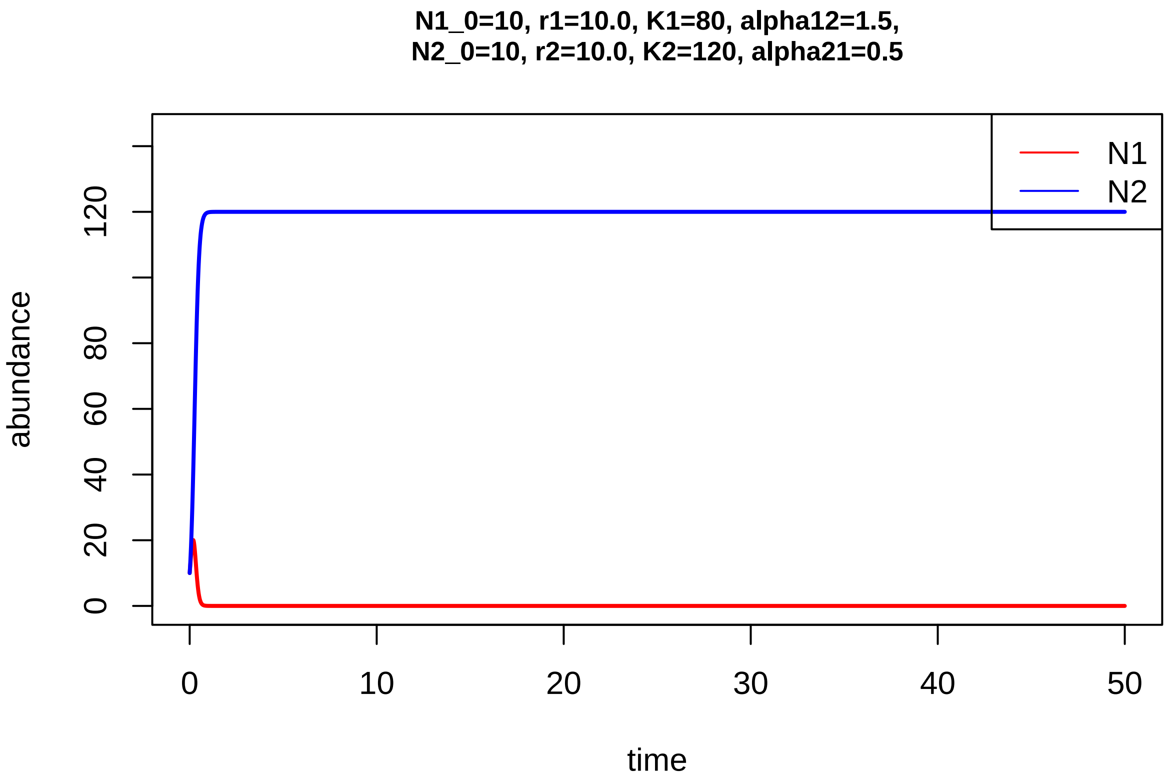
$$K1/\alpha_{12} = 53.3 < K2 = 120$$

$$K2/\alpha_{21} = 240 > K1 = 80$$

(ii) Species 2 is the suprior competitor. Species 2 has a stronger ability to presist under competitive pressure and limits itself less than it limits Species 1. This is due to Species 2's lower interspecific affect. Species 1 is more sensitive to competition from Species 2. Species 2 excludes Species 1.

(iii) Example Parameters

```
lvCompetition(N1_0=10, r1=10, N2_0=10, r2=10,
                    K1=80, K2=120, alpha12=1.5, alpha21=0.5, endTime=50)
```



- Species 2 (blue) rapidly increases and dominates over Species 1 (red). Species 1 (red) goes to zero and therefore extinction. Classic example of competitive exclusion.

Exercise 2

(1)

$$\alpha_{12} = 0.8$$

and

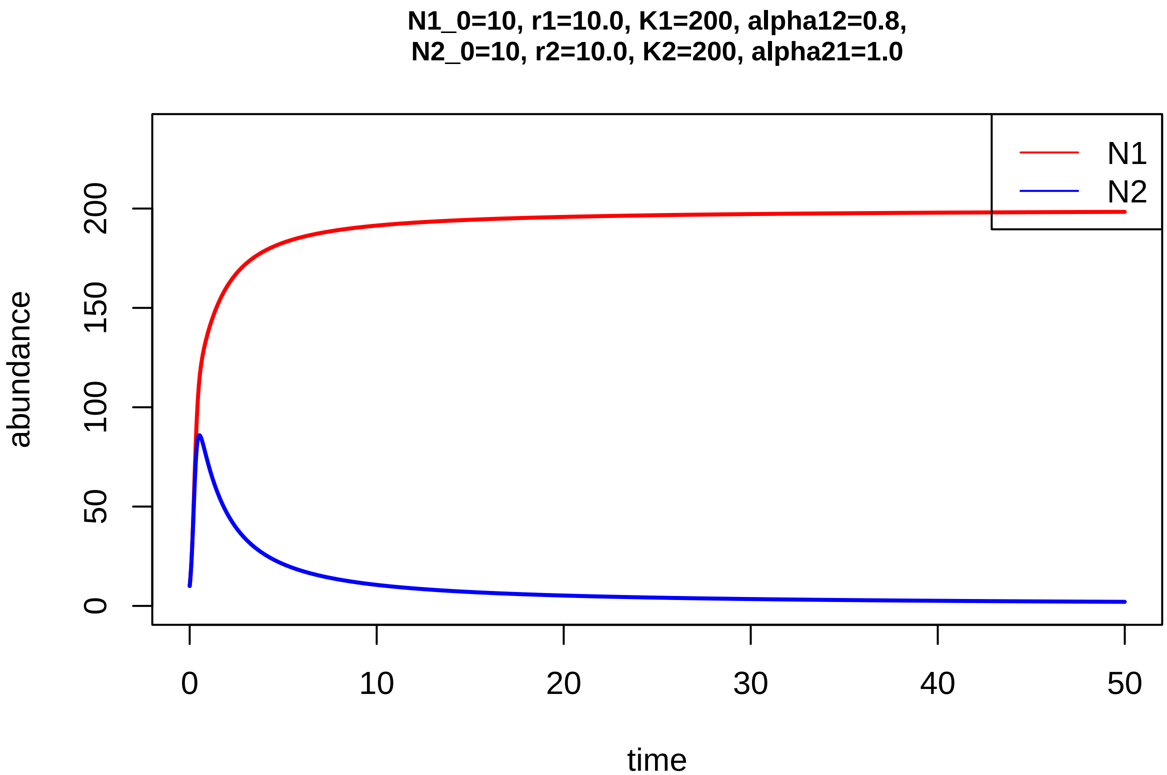
$$\alpha_{21} = 1.0$$

$$K1/\alpha_{12} = 200/0.8 = 250$$

$$K2/\alpha_{21} = 200/1.0 = 200$$

* Since both are greater than 200, the condition for stable coexistence is not met, so this is an unstable system. The species with the slightest competitive advantage slowly drives the other one to extinction.

```
lvCompetition(N1_0=10, r1=10, N2_0=10, r2=10,
                             K1=200, K2=200, alpha12=0.8, alpha21=1.0, endTime=50)
```



- The time to exclusion is long here as we see that both species persist for a while. In an unstable system with low intensity competition, exclusion takes longer which allows for temporary coexistence.

(2)

$$\alpha_{12} = 0.8$$

and

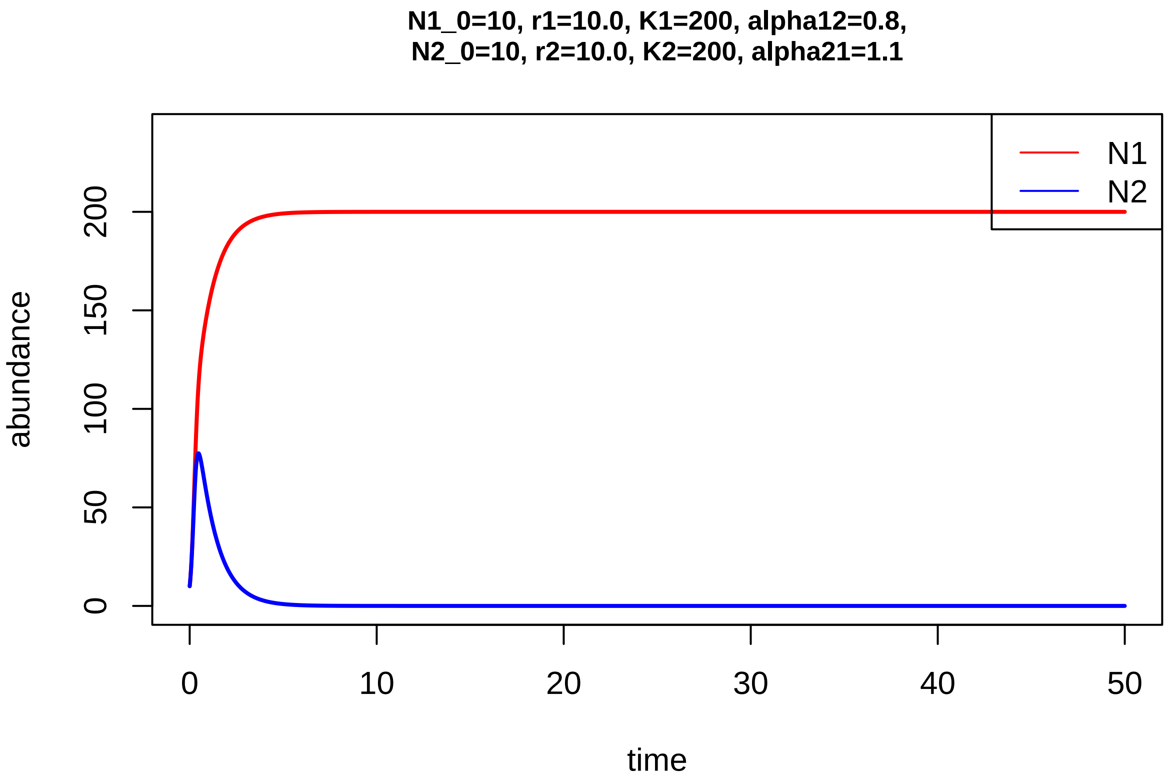
$$\alpha_{21} = 1.1$$
$$K2/\alpha_{21} = 200/1.1 = 181.8$$

which is,

$$< K1 = 200$$

* This remains unstable as well.

```
lvCompetition(N1_0=10, r1=10, N2_0=10, r2=10,
                         K1=200, K2=200, alpha12=0.8, alpha21=1.1, endTime=50)
```



- We see that exlcusion happens sooner than in the previous plot. The time to exclusion is slightly shorter than the previous conditions meaning that the competition is more intense. So, we can conclude that as alpha21 increases, species 2 harms species 1 more leading to faster exclusion.

(3)

$$\alpha_{12} = 0.8$$

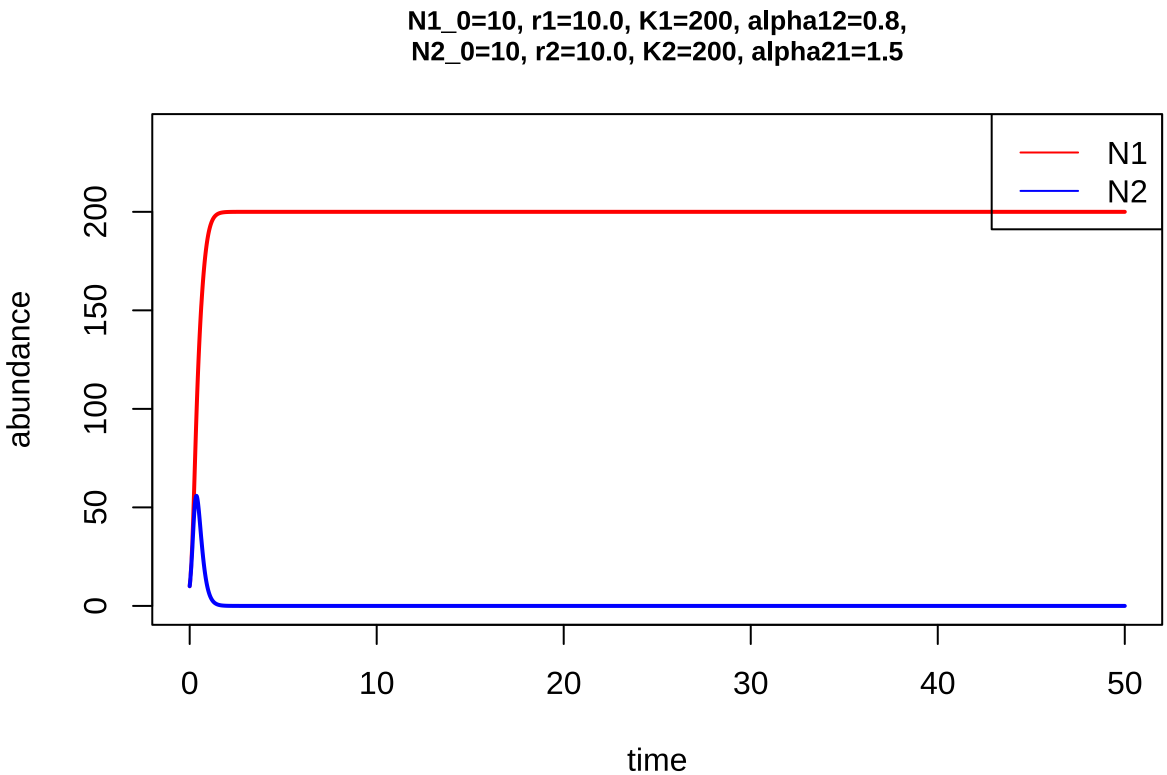
and

$$\alpha_{21} = 1.5$$

$$K2/\alpha_{21} = 200/1.5 = 133.3$$

* Well below 200, so unstable system.

```
lvCompetition(N1_0=10, r1=10, N2_0=10, r2=10,
                         K1=200, K2=200, alpha12=0.8, alpha21=1.5, endTime=50)
```



- Rapid competitive exclusion of one species. Time to exclusion much faster than previous case so trend becoming more obvious that as alpha21 increases, time to exclusion decreases. As the competition becomes stronger, dominant species excludes the weaker one more quickly.

(4)

$$\alpha_{12} = 0.8$$

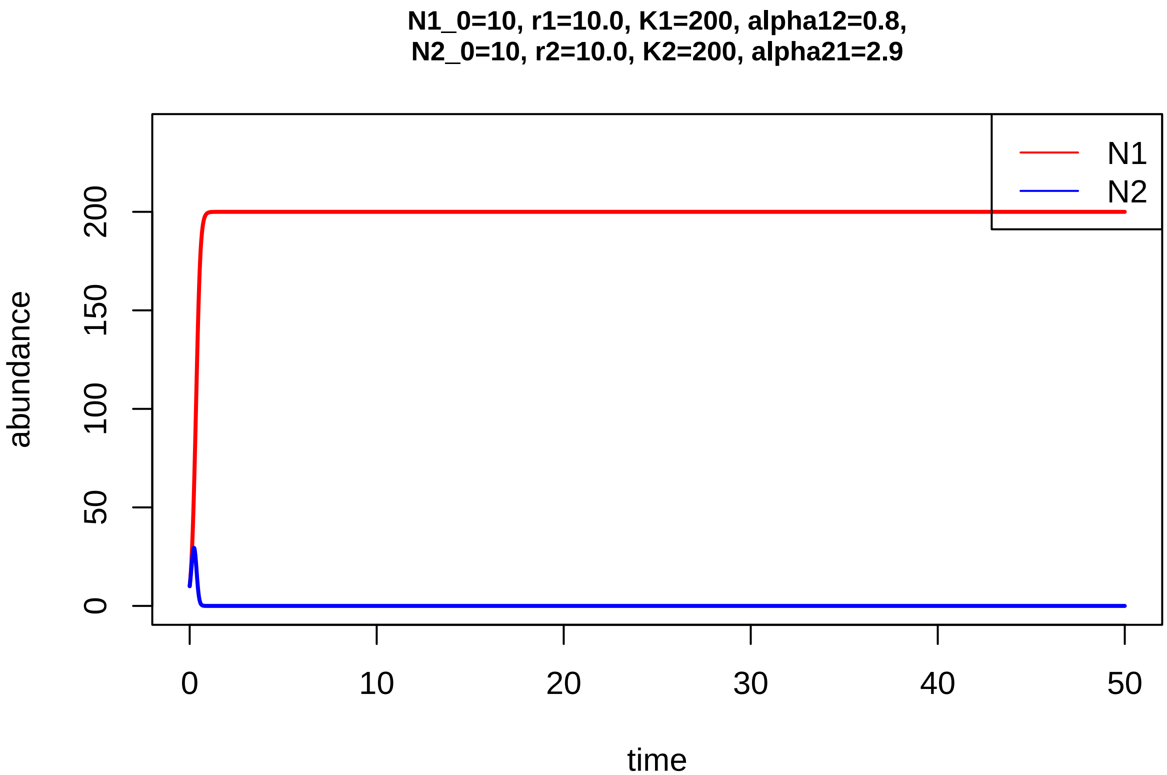
and

$$\alpha_{21} = 2.9$$

$$K2/\alpha_{21} = 200/2.9 = 69$$

* This if far below K1 = 200, so this is a very unstable system with extreme asymmetry.

```
lvCompetition(N1_0=10, r1=10, N2_0=10, r2=10,
                        K1=200, K2=200, alpha12=0.8, alpha21=2.9, endTime=50)
```

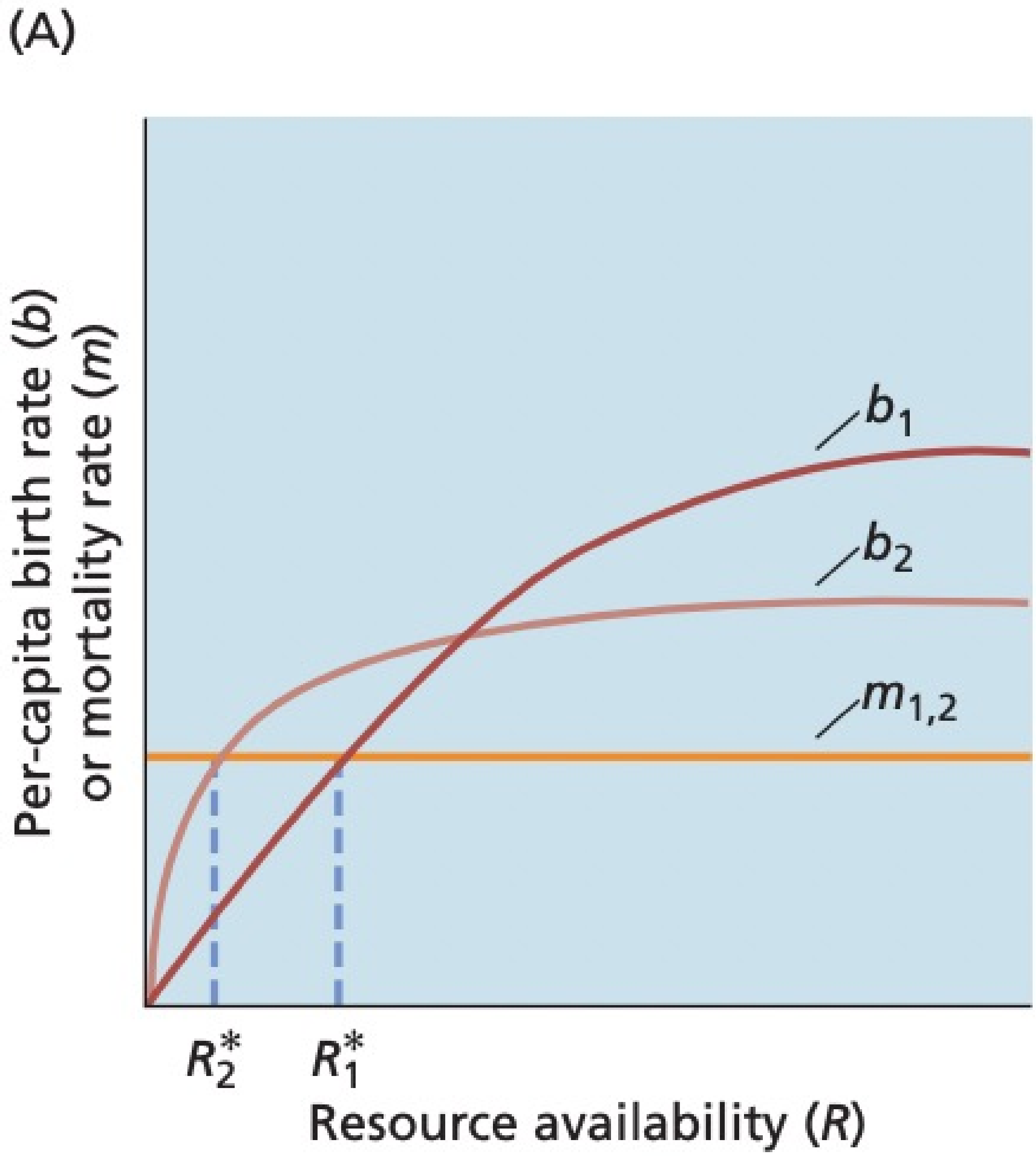


- One species crashes almost immediately. The time to exclusion is the fastest exclusion time compared to all of the previous plots. This aligns with our assumption that as the alpha21 value increases, the time to exclusion becomes quicker reached. So, high-intensity interspecific competition leads to rapid extinction in unstable systems.
- In general, we see that in unstable systems, higher competition intensity leads to faster exclusion. When interspecific effects are only slightly stronger than intraspecific ones, the losing species persists for some time. But as the competitive imbalance increases, time to extinction drops sharply, eliminating any chances of coexistence.

Exercise 3

- In ecosystems not at equilibrium, like those experiencing frequent disturbances or constant immigration, the time to exclusion is a significant factor in diversity. In the case where competitive exclusion takes a long time, both species can coexist temporarily even if one is predicted or bound to be outcompeted eventually. In the case where there is continuous immigration, species that would be excluded under stable conditions are able to persist. This would be considered a non-equilibrium balance where the species richness is maintained by the offset by arrival of new individuals. In the case where there is high turnover and stable diversity, the number of species would remain relatively high due to the constant flux. The observed diveristy accounts for the time to exclusion (slower = more coexistence) and the rate of immigration (faster = more persistence of weak competitors).

Exercise 4



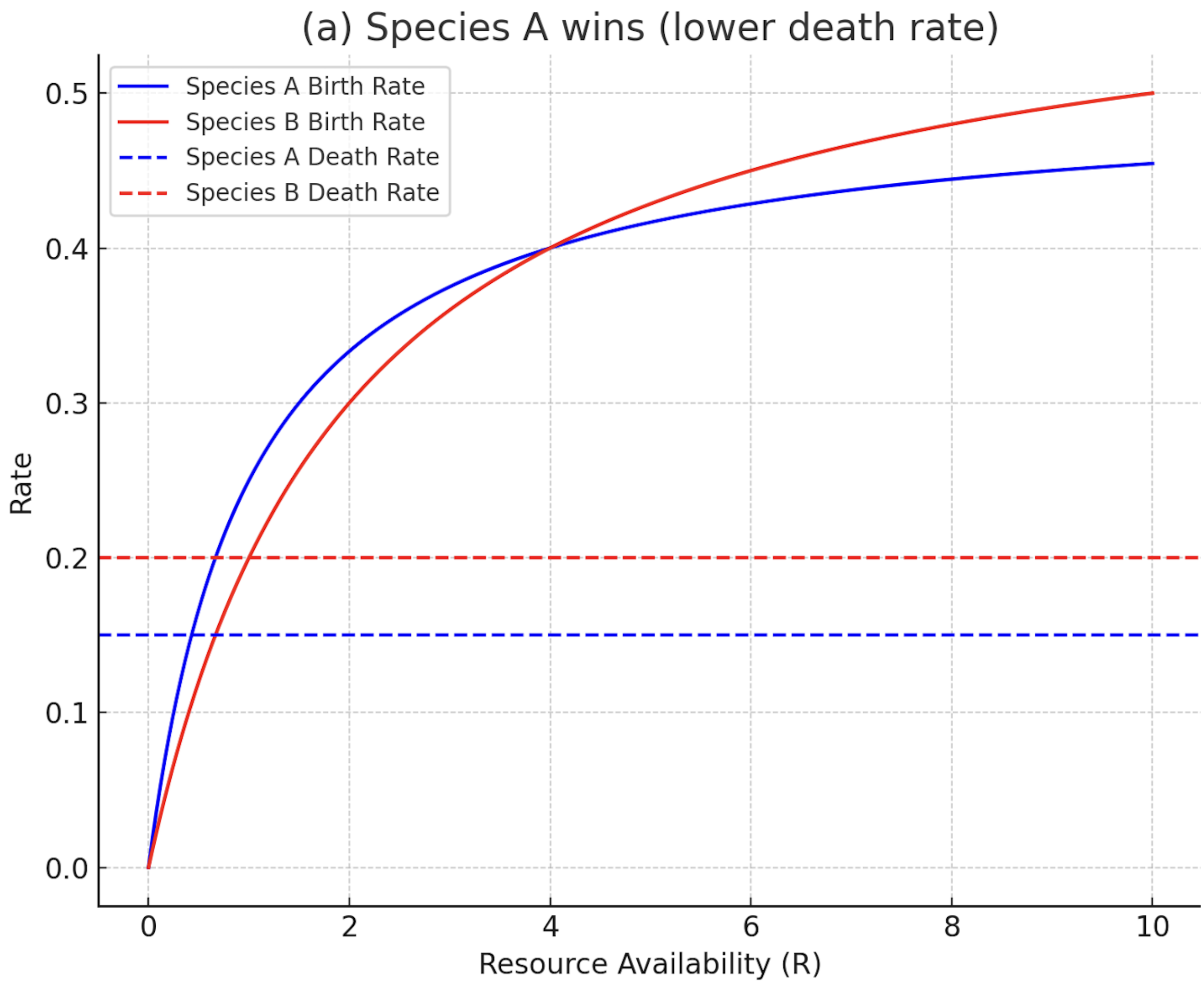
- Species A (red) has a lower Rstar which means it can persist at lower resource levels. Species B (orange) needs more resources for a higher Rstar. Both species face the same density-independent death rates (the dashed black line). Rstar is marked where each species birth rate intersects the death rate.

$$R_A^* < R_B^*$$

* Since Species A has the lower Rstar, it will outcompete and exclude Species B in the long term in a resource-limiting environment.

Exercise 5

a)



- Species A (blue) has a lower death rate than Species B. Even though both species' birth rates are shown, A's curve crosses the death line as a lower R value. This may mean that Species A can persist at a lower resource level. So, this is why it wins and excludes Species B.

b)

- In this case, Species B (red) has the lower death rate, while Species A's death rate is raised. Now, the Rstar of B is lower than that of A's, so B can survive with less resources. Species B wins and this is the reversal of the results from exercise 4's plot.

c)

- In R theory, the winner of resource competitions are the species that can survive and reproduce at the lowest resource level, which is the lowest Rstar. When death rates are equal, the species with a better birth rate curve will win. When the death rates differ, Rstar is shifted and includes information about resources. A higher death rate will equal a higher Rstar and a lower death rate will equal a lower Rstar.

Exercise 6

a) 3 criteria for stable coexistence

- To get stable coexistence in a case where two species are competing for two resources:

1. Each species must be limited more by the resource it uses less efficiently. Neither species will be the best at using both resources. So, Species A can be better at utilizing resource 1, but also be more limited by resource 2.
2. Each species must consume more of the resource that limits its own growth. The species need to self-limit by limiting their own resource more than limiting the competitors resource. This is kind of the idea of niche differentiation. which would result in a low chance of one species outcompeting the other.
3. A resource supply point that supports growth for both species. If it is in a region where both species can increase when rare, both of those species can persist.

b) Analyze Phase Plane

- Sector 4 is between the two dashed consumption vectors. In this region, both species can increase in number. This allows stable coexistence because each species consumes more of the resource that limits its own growth (the direction of the C vectors) and neither species drives the other extinct. Instead, both reach stable equilibrium by balancing consumption and limitations on resources.