Lab 8: Parasitism

Basic instructions:

For today's lab, the 'Infectious microparasitic diseases' module will be used. To get to this module, click on 'Multi species dynamics' then on 'host-parasite models'. For all questions, set 'Model version' to SIR model with DD transmission

Mathematical background:

For this lab, a slightly more complicated model of infectious microparasites will be used than the one presented in class. The Populus help file provides an adequate description of this more complicated model. In short, the simulations run by Populus use the following differential equations which describe the instantaneous rate of change for the density of **S**usceptible individuals, **I**nfected individuals, and **R**esistant individuals:

$$\frac{dS}{dt} = b(S + I + R) - dS - \beta SI + \gamma R$$

$$\frac{dI}{dt} = \beta SI - (\alpha + d + v)I$$

$$\frac{dR}{dt} = vI - (d + \gamma)R$$

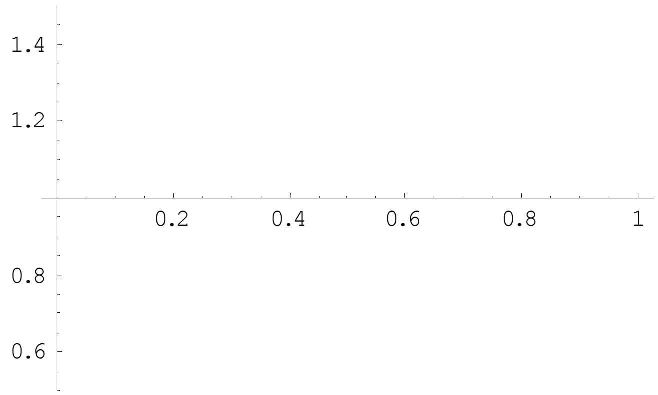
In these equations, b is the birth rate of the host, β is the probability of transmission , d is the disease independent host death rate , γ is the rate at which resistant hosts lose their immunity, α is the disease induced host death rate (virulence), and v is the rate at which hosts recover and become immune.

Questions:

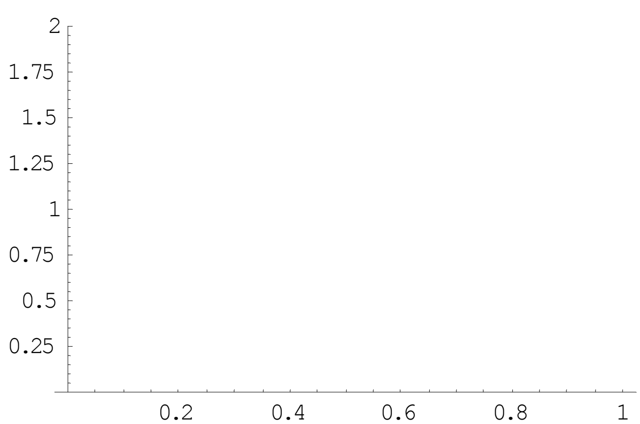
1. For this model, derive a general mathematical expression for R_0, the basic reproductive number of the disease.

2. Using your answer to 1, draw the following graphs:

A. Assume that $\beta = \frac{1}{2}$, $S = 2$, $d = \frac{1}{4}$, and $v = \frac{1}{2}$. Plot the R_0 of this disease as a function of α, the disease induced host death rate (virulence). How does increasing the disease virulence affect the R_0 of the disease? Why? Check your work using Populus.



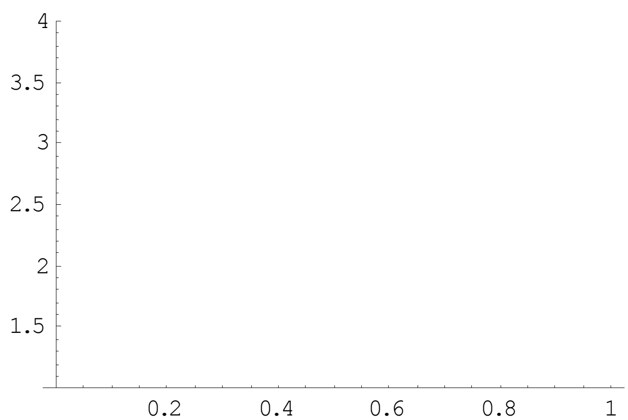
B. Assume that $\alpha = \frac{1}{2}$, $S = 2$, $d = \frac{1}{4}$, and $v = \frac{1}{2}$. Plot the R_0 of this disease as a function of β, the disease transmissibility. How does increasing the disease transmissibility affect the R_0 of the disease? Why? Check your work using Populus.



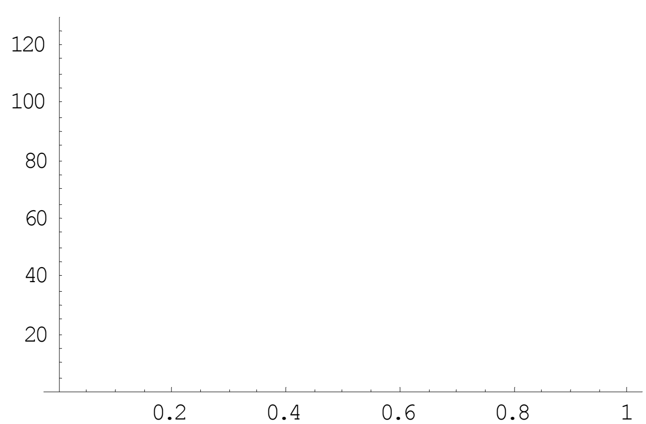
3. Derive a general mathematical expression for the minimum number of susceptible individuals required for this disease to spread.

4. Using your answer to 3, draw the following graphs:

A. Assume that $\beta = ½$, $d = ¼$, and $v = ½$. Plot the S_{crit} of this disease as a function of α, the disease induced host death rate (virulence). How does increasing the disease virulence affect the S_{crit} of the disease? Why? Check your work using Populus.



B. Assume that $\alpha = ½$, $d = ¼$, and $v = ½$. Plot the S_{crit} of this disease as a function of β, the disease transmissibility. How does increasing the disease transmissibility affect the S_{crit} of the disease? Why? Check your work using Populus.



5. Based upon your answers to the previous questions, why might a highly virulent disease like Ebola fail to spread through the human population? Under what conditions might such a highly virulent disease spread?