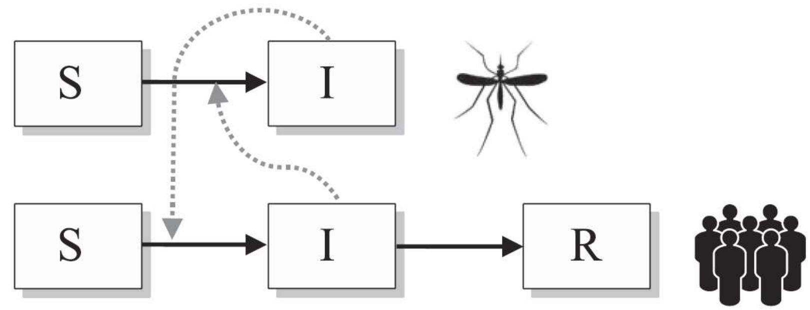
Problem Set – Multi-host (10 Points)

- Consider a model for Malaria
  - Model 4.16 from Keeling and Rohani, Online program 4.4
- Show that

$$R_0 = \frac{b^2 T_{HM} T_{MH} N_M}{\mu_M(\gamma_H + \mu_H) N_H}.$$

- Controls for malaria can include:
  - Reducing biting rate using insecticides or bednets
  - Providing pharmaceuticals that increase the recovery rate of humans
- Implement the control mechanisms into the model
  - Write the new system of equations
  - Run the online program 4.4 with the modifications



$$\frac{dX_H}{dt} = \nu_H - r T_{HM} Y_M X_H - \mu_H X_H,$$
$$\frac{dY_H}{dt} = r T_{HM} Y_M X_H - \mu_H Y_H - \gamma_H Y_H,$$
$$\frac{dX_M}{dt} = \nu_M - r T_{MH} Y_H X_M - \mu_M X_M,$$
$$\frac{dY_M}{dt} = r T_{MH} Y_H X_M - \mu_M Y_M,$$

$$r = \frac{b}{N_H},$$

- Discuss whether it would be more cost effective to reducing biting rates vs increase the use of pharmaceuticals

Problem Set – Multi-Pathogen (10 Points)

- Consider a model for Partial Cross Immunity
  - Model 4.6 from Keeling and Rohani
  - Online program 4.1
- Assume $\beta_1 = \frac{260}{365}, \gamma_1 = \frac{1}{7}, \nu = \mu$
  $\mu = \frac{1}{(70)(365)}, \alpha_1 = 0.5, a_1 = 0.4$
- Find sets of $(\beta_2, \alpha_2, \alpha)$ that allow for Strain 2 to grow in the population

$$\frac{dN_{SS}}{dt} = \nu - \beta_1 N_{SS} I_1 - \beta_2 N_{SS} I_2 - \mu N_{SS},$$

$$\frac{dN_{IS}}{dt} = \beta_1 N_{SS} I_1 - \gamma_1 N_{IS} - \mu N_{IS},$$

$$\frac{dN_{RS}}{dt} = \gamma_1 N_{IS} - \alpha_2 \beta_2 N_{RS} I_2 - \mu N_{RS},$$

$$\frac{dN_{SI}}{dt} = \beta_2 N_{SS} I_2 - \gamma_2 N_{SI} - \mu N_{SI},$$

$$\frac{dN_{RI}}{dt} = \alpha_2 \beta_2 N_{RS} I_2 - \gamma_2 N_{RI} - \mu N_{RI},$$

$$\frac{dN_{SR}}{dt} = \gamma_1 N_{IS} - \alpha_1 \beta_1 N_{SR} I_1 - \mu N_{RS},$$

$$\frac{dN_{IR}}{dt} = \alpha_1 \beta_1 N_{SR} I_1 - \gamma_1 N_{IR} - \mu N_{IR},$$

$$\frac{dN_{RR}}{dt} = \gamma_1 N_{IR} + \gamma_2 N_{RI} - \mu N_{RR},$$

$$I_1 = N_{IS} + a_1 N_{IR}, \qquad I_2 = N_{SI} + a_2 N_{RI},$$