Set 9: Competitive exclusion and predator-prey dynamics

Rakshit Pandhi (202201426)* and Kalp Shah (202201457)†
Dhirubhai Ambani Institute of Information & Communication Technology, Gandhinagar, Gujarat 382007, India
CS302, Modeling and Simulation

In this lab, we studied the Principle of competitive exclusion and modeled the population growth of two similar species. We also modeled predator-prey dynamic with and without human. interference.

I. COMPETITIVE EXCLUSION

In Nature, it happens often that two similar species compete for resources and living space within the same ecological territory. The outcome of this competition is usually the extinction of one species. This is known as the Principle of Competitive Exclusion. Let the population densities of X-species be x(t) and of Y species be y(t).

A. Model Equations

$$\frac{dx}{dt} = Ax - Bx^2 - \alpha xy \tag{1}$$

$$\frac{dy}{dt} = Cy - Dy^2 - \beta xy \tag{2}$$

B. Results

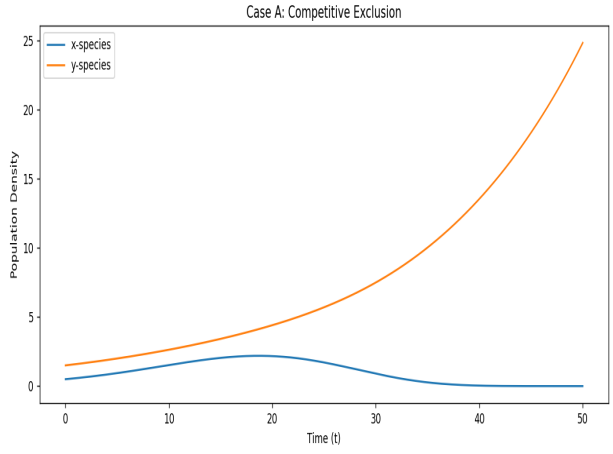

FIG. 1: Peak values X=2.19 and Y grows forever A=0.21827, B=0, C=0.06069, D=0 , $\alpha = 0.05289, \beta = 0.00459, x_0 = 0.5, \delta t = 0.0001$

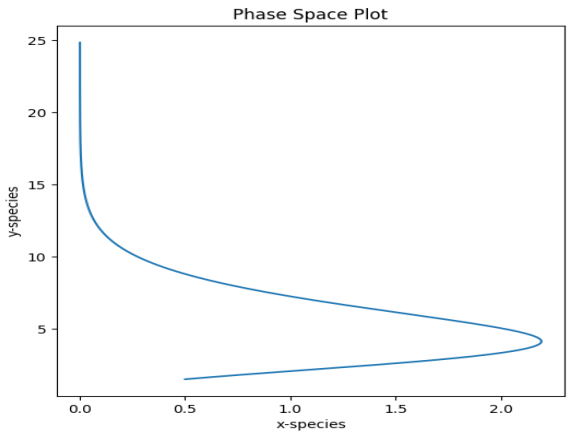

FIG. 2: Phase plot

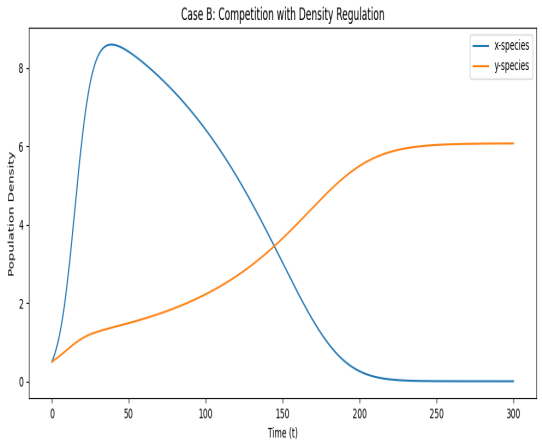

FIG. 3: Peak values X=8.58 and Y=6.06 A=0.21827, B=0.017, C=0.06069, D=0.01 , $\alpha = 0.05289, \beta = 0.00459, x_0 = 0.5, y_0 = 0.5, \delta t = 0.0001$

*Electronic address: 202201426@daiict.ac.in
†Electronic address: 202201457@daiict.ac.in

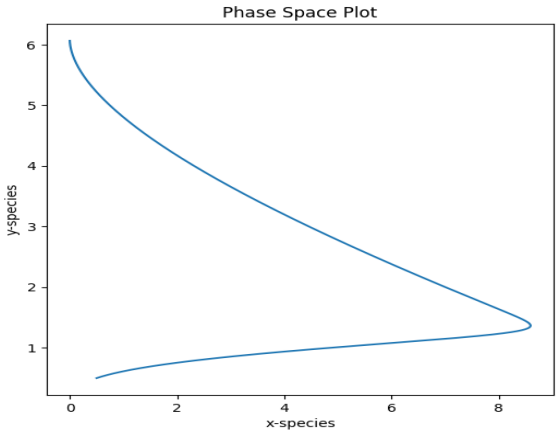

FIG. 4: Phase plot

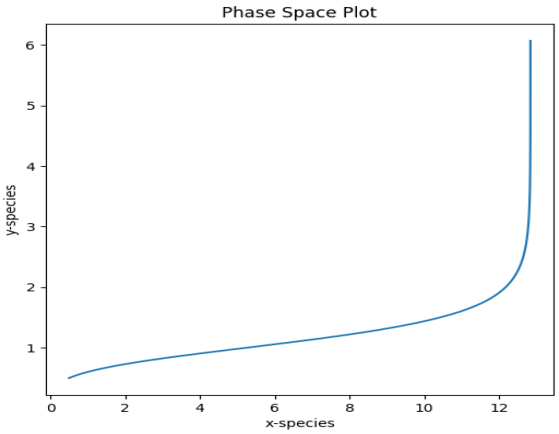

FIG. 6: Phase plot

II. PREDATOR - PREY DYNAMICS

A. Model Equations

The Lanchester model equations for the Battle of Trafalgar are given by:

$$\frac{dx}{dt} = Ax - Bxy - \epsilon x \tag{3}$$

$$\frac{dy}{dt} = -Cy + Dxy - \epsilon y \tag{4}$$

B. Results

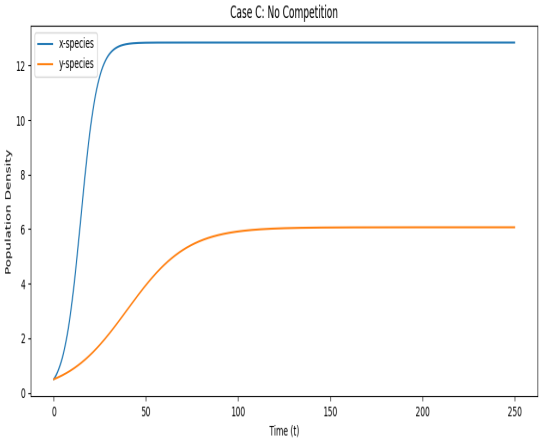

FIG. 5: Peak values X=12.84 and Y=6.06 A=0.21827, B=0.017, C=0.06069, D=0.01 , $\alpha = 0, \beta = 0, x_0 = 0.5, y_0 = 0.5, \delta t = 0.0001$

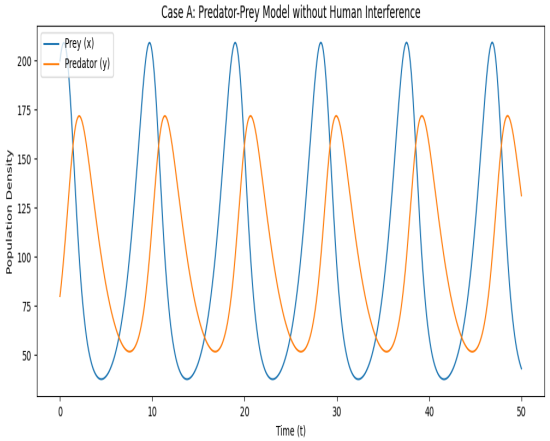

FIG. 7: Peak values Prey=209.18, Predator= 171.71, A=1, B=0.01, C=0.5, D=0.005, $x_0 = 200, y_0 = 80, \epsilon = 0, \delta t = 0.0001$

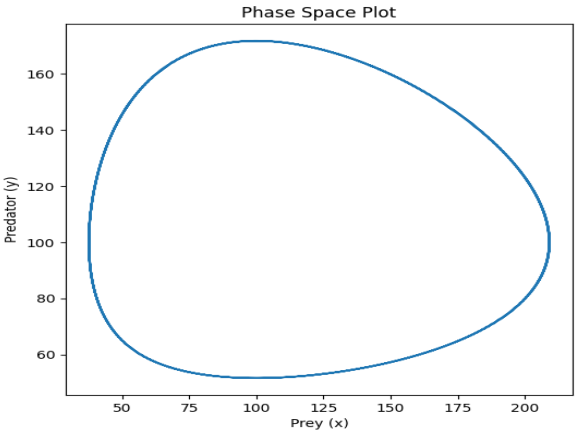

FIG. 8: Phase plot

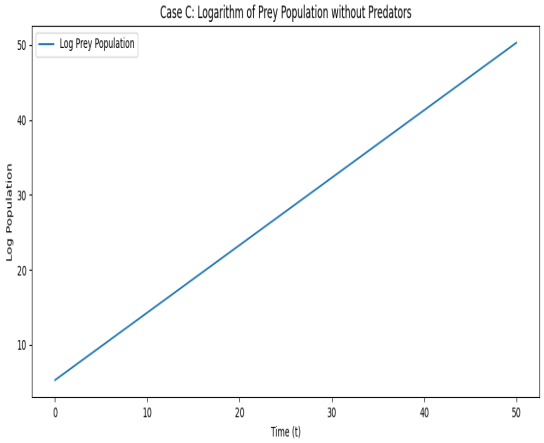

FIG. 11: Population density of prey without predator in log scale. Increases with time , $x_0 = 200, y_0 = 0$

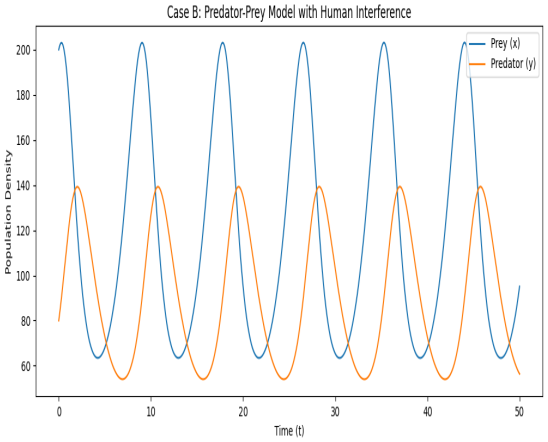

FIG. 9: Peak values Prey=202.160, Predator= 139.21, A=1, B=0.01, C=0.5, D=0.005, $x_0 = 200, y_0 = 80, \epsilon = 0.1, \delta t = 0.0001$

Due to human interference, the peak value of prey decreases by about 8 units, whereas the peak value of predators decreases by about 30 units, indicating that human interference benefits the prey.

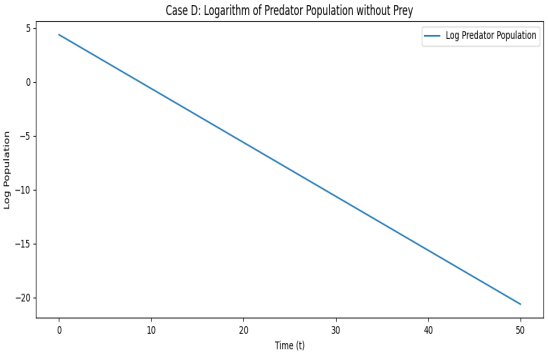

FIG. 12: Population density of predator without prey in log scale. Decreases with time eventually extinct, $x_0 = 0, y_0 = 80$

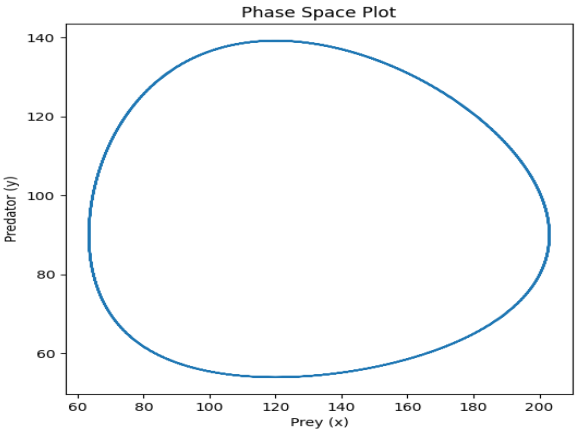

FIG. 10: Phase plot