Set - 9 : Competitive exclusion and predator-prey dynamics

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CS302, Modelling and Simulation

I. COMPETITIVE EXCLUSION

A. Model

In Nature it happens often that two similar species compete for resources and living space within the same ecological territory.
Let the population densities (number per unit area) of an X-species be x(t) and of a Y-species be y(t). The growth of x and y is modelled by the coupled equations

$$\dot{x} = Ax - Bx^2 - \alpha xy \tag{1}$$

$$\dot{y} = Cy - Dy^2 - \beta xy \tag{2}$$

Euler's formulas for x(t) and y(t) are

$$x(i) = x(i-1) + dx(x(i-1), y(i-1)) * \Delta t \tag{3}$$

$$y(i) = y(i-1) + dy(x(i-1), y(i-1)) * \Delta t \tag{4}$$

where dx(x,y)=$\dot{x}$ and dy(x,y)=$\dot{y}$.

B. Results

1. *No competition within the species*

Fig. 1 shows population density of a species vs time.

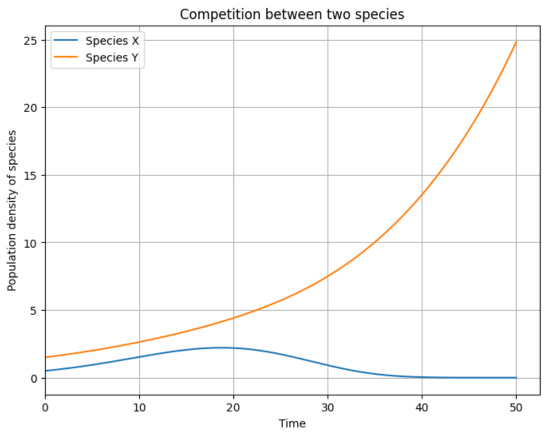

FIG. 1: Here x(0) = 0.5, y(0) = 1.5, A = 0.21827, B = 0 , C = 0.06069, D = 0, $\alpha = 0.05289, \beta = 0.00459, \Delta t = 0.0001$.

Fig. 2 shows population density of a Y-species vs population density of a X-species.

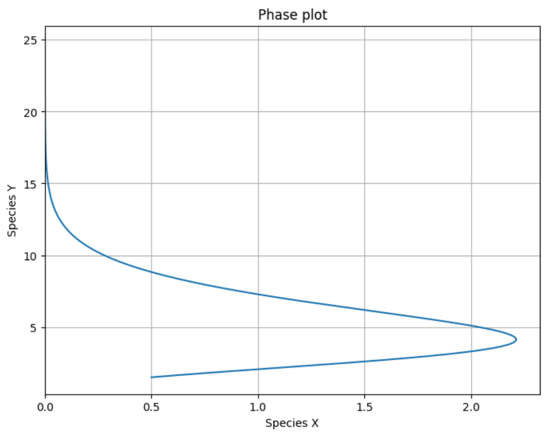

FIG. 2: Here x(0) = 0.5, y(0) = 1.5, A = 0.21827, B = 0 , C = 0.06069, D = 0, $\alpha = 0.05289, \beta = 0.00459, \Delta t = 0.0001$.

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2. *Competition within the species*

Fig. 3 shows population density of a species vs time.

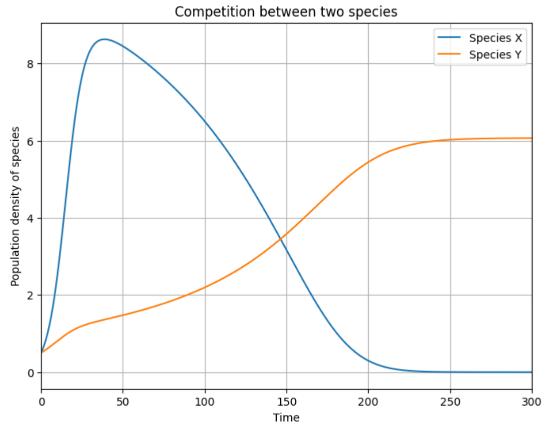

FIG. 3: Here x(0) = 0.5, y(0) = 0.5, A = 0.21827, B = 0.017 , C = 0.06069, D = 0.010, $\alpha = 0.05289, \beta = 0.00459, \Delta t = 0.0001$.

Time at which x attains its maxima value is : 38.75 years.
The maximum value of x : 8.62.
The maximum value of y : 6.06.

Fig. 4 shows population density of a Y-species vs population density of a X-species.

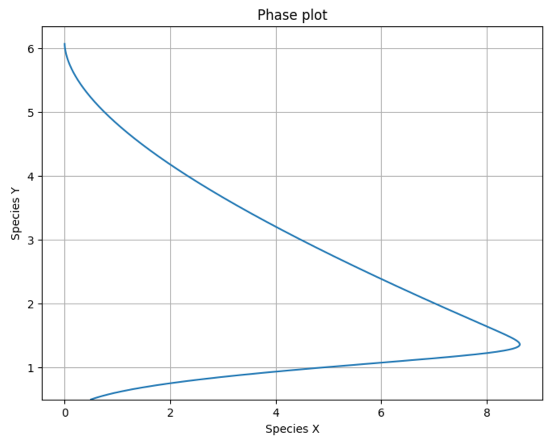

FIG. 4: Here x(0) = 0.5, y(0) = 0.5, A = 0.21827, B = 0.017 , C = 0.06069, D = 0.010, $\alpha = 0.05289, \beta = 0.00459, \Delta t = 0.0001$.

3. *No inter species competition*

Fig. 5 shows population density of a species vs time.

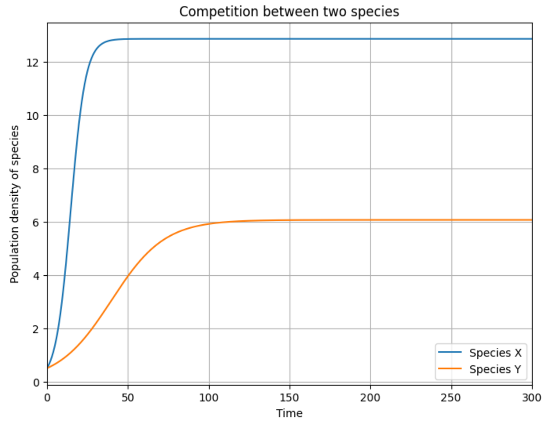

FIG. 5: Here x(0) = 0.5, y(0) = 0.5, A = 0.21827, B = 0.017 , C = 0.06069, D = 0.010, $\alpha = 0, \beta = 0, \Delta t = 0.0001$.

Fig. 6 shows population density of a Y-species vs population density of a X-species.

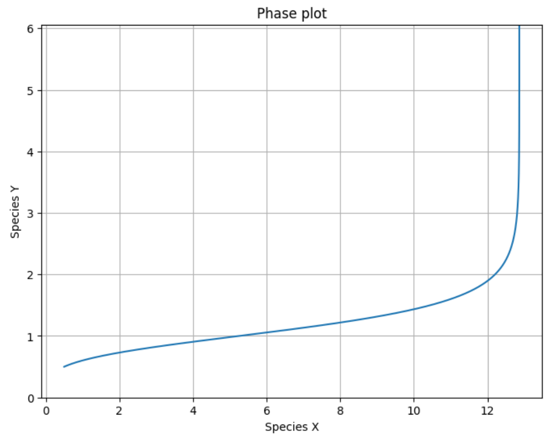

FIG. 6: Here x(0) = 0.5, y(0) = 0.5, A = 0.21827, B = 0.017 , C = 0.06069, D = 0.010, $\alpha = 0, \beta = 0, \Delta t = 0.0001$.

Peak value of X-species:12.84
Peak value of Y-species:6.07

II. PREDATOR-PREY DYNAMICS

A. Model

In the interaction between a prey species X and a predator species Y, let the population densities (number per unit area) of the X-species (prey) be x(t) and of the Y-species (predator) be y(t). The growth of x and y is modelled by the coupled equations

$$\dot{x} = Ax - Bxy - \epsilon x \tag{5}$$

$$\dot{y} = -Cy + Dxy - \epsilon y \tag{6}$$

Euler's formulas for x(t) and y(t) are

$$x(i) = x(i-1) + dx(x(i-1), y(i-1)) * \Delta t \qquad (7)$$

$$y(i) = y(i-1) + dy(x(i-1), y(i-1)) * \Delta t \qquad (8)$$

where dx(x,y)=$\dot{x}$ and dy(x,y)=$\dot{y}$.

B. Results

1. *Without fishing(Without human interference)*

Fig. 7 shows population density of a species vs time.

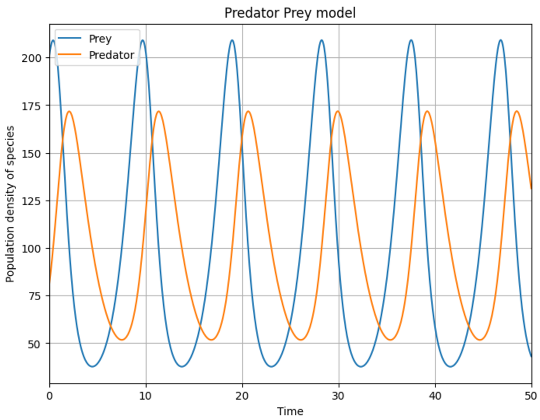

FIG. 7: Here x(0) = 200, y(0) = 80, A = 1.0, B = 0.01, C = 0.5, D = 0.005, $\epsilon = 0, \Delta t = 0.0001$.

Fig. 8 shows population density of a Y-species vs population density of a X-species.

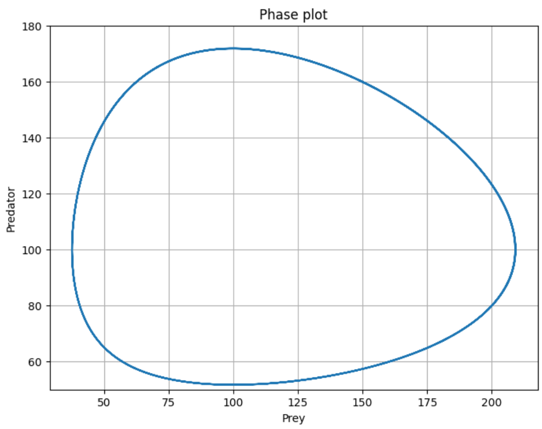

FIG. 8: Here x(0) = 200, y(0) = 80, A = 1.0, B = 0.01, C = 0.5, D = 0.005, $\epsilon = 0, \Delta t = 0.0001$.

The maximum value of y : 171.71.

2. *With fishing(Human interference)*

Fig. 9 shows population density of a species vs time.

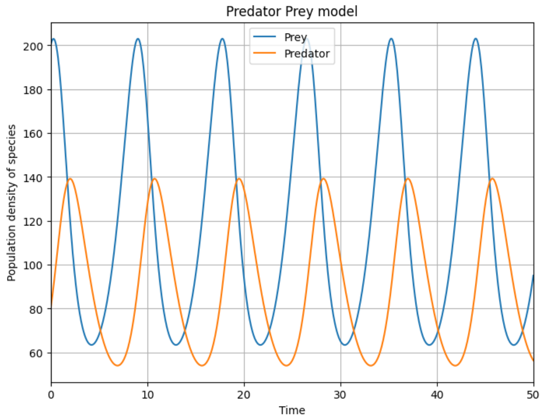

FIG. 9: Here x(0) = 200, y(0) = 80, A = 1.0, B = 0.01, C = 0.5, D = 0.005, $\epsilon = 0.1, \Delta t = 0.0001$.

Fig. 10 shows population density of a Y-species vs population density of a X-species.

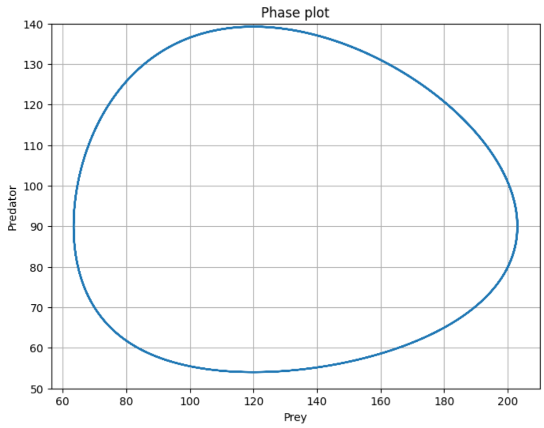

FIG. 10: Here x(0) = 200, y(0) = 80, A = 1.0, B = 0.01, C = 0.5, D = 0.005, $\epsilon = 0.1, \Delta t = 0.0001$.

The maximum value of y : 139.201.

The maximum value of Y-species is greater when there is no human interference(without fishing).

3. *No predator*

Fig. 11 shows population density of a X-species(logarithmic) vs time.

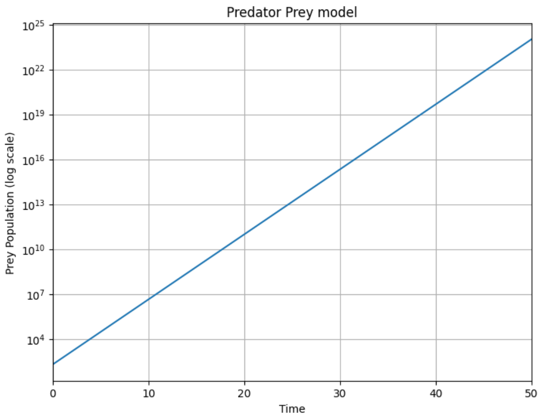

FIG. 11: Here x(0) = 200, y(0) = 0, A = 1.0, B = 0.01, C = 0.5, D = 0.005, $\epsilon = 0, \Delta t = 0.0001$.

Here the X-species(logarithmic scale) is linearly increase when there is no predator(Y-species).

4. *No prey*

Fig. 12 shows population density of a Y-species(logarithmic) vs time.

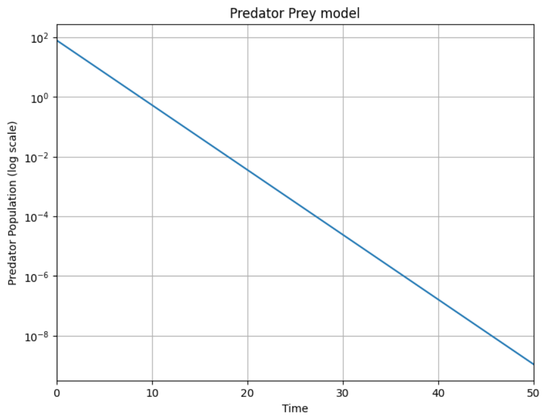

FIG. 12: Here x(0) = 0, y(0) = 80, A = 1.0, B = 0.01, C = 0.5, D = 0.005, $\epsilon = 0, \Delta t = 0.0001$.

Here the Y-species(logarithmic scale) is linearly decrease when there is no prey(X-species).