SIMIODE PROBLEM C: CHEMICAL ESPIONAGE

PR-C-Texas A&M University-Kingsville-Team-4
Ayat Hamide
Danial Lerma
Stephen Cardenas
Coach: Dongwook Kim

SCUDEM IV 2019 PURPOSE:

- Developing a mathematical model from interaction of two species in the ecosystem.
- Finding the best balance for the interaction of the two species.
- Giving some assumption to show what could happen in the long run.
- Studying the behavior of the system by simulation

THE PROBLEM:

- In our case, the problem was in the ecosystem between two species the butterflies and wasps. The interaction of male and female butterflies is related to the interaction of wasps to butterflies themselves.
- Male butterflies mate with female, they release a chemical signal, called an anti-aphrodisiac.
- Anti-aphrodisiac makes the female butterflies less likely to be bothered by males, so they can focus on placing their eggs on in the most advantageous place. But on the other hand, this anti-aphrodisiac will cause other insects which is wasps to be detecting the females and lay their eggs on the top of butterflies eggs



APPROACHING THE PROBLEM:

- As team we decided to approach the problem using a predator- prey model.
- Predator-prey model requires using latka-Volterra equations,

$$\frac{dx}{dt} = \boldsymbol{\alpha} x - \boldsymbol{\beta} xy \quad (1)$$

$$\frac{dy}{dt} = \boldsymbol{\delta} xy - \boldsymbol{\gamma} y \quad (2)$$

- Where $\frac{dx}{dt}$ and $\frac{dy}{dt}$ are representing the instantaneous growth rates of the two populations to respect of time. Where, alpha is the birth rate of the prey population, and beta is the rate of interaction between the predator and prey species.
- There were many assumptions made to be able to describe this basic predator-prey relationship between the two species.

THE MODEL

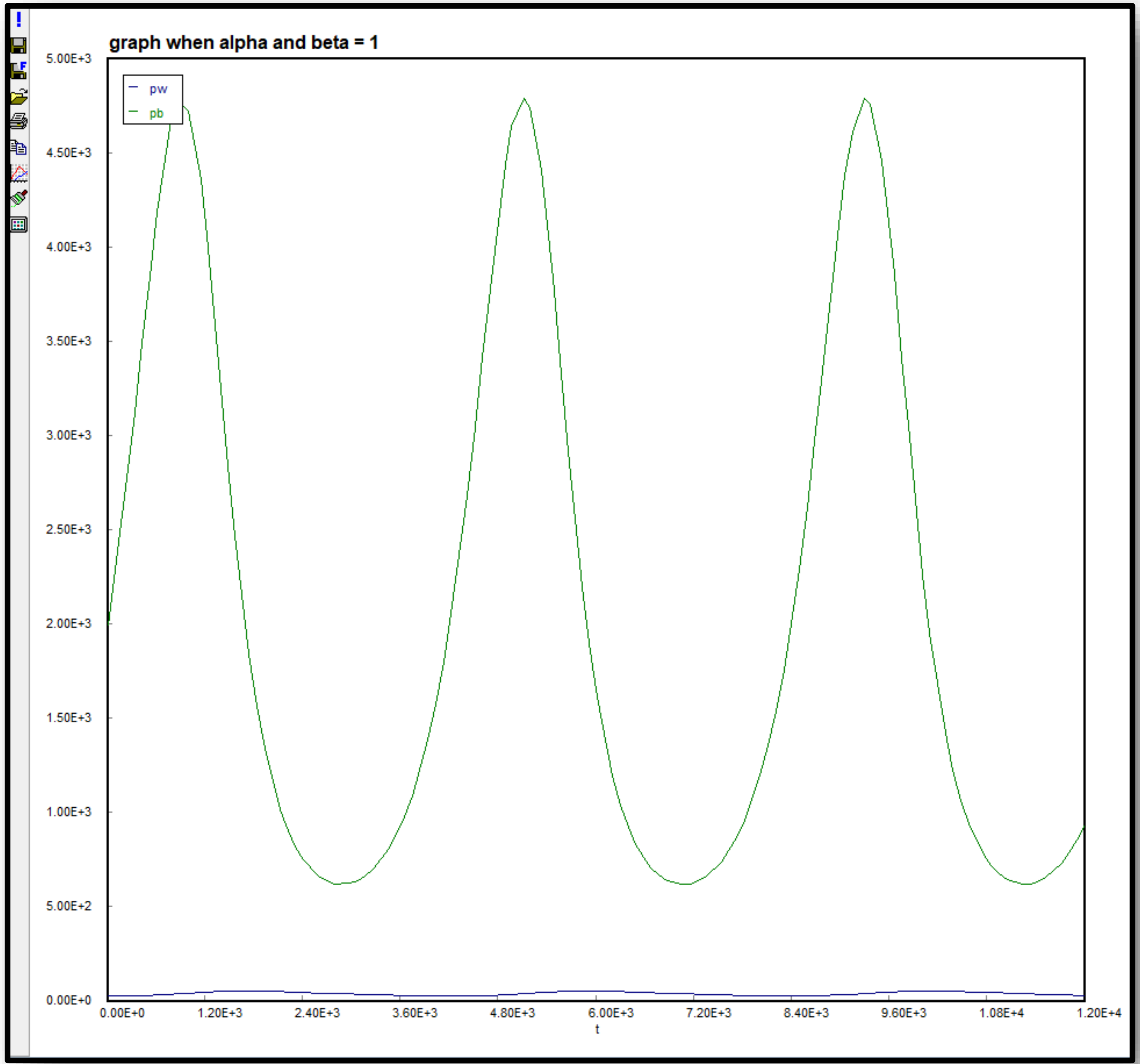
$$\frac{dP_b}{dt} = \alpha k_1 P_b \left(1 - \frac{P_b}{k_2}\right) - \alpha\beta P_b P_w - k_3 P_b$$

$$\frac{dPw}{dt} = -k_4 P_w + k_5\, \alpha\beta P_b P_w + k_6 P_w$$

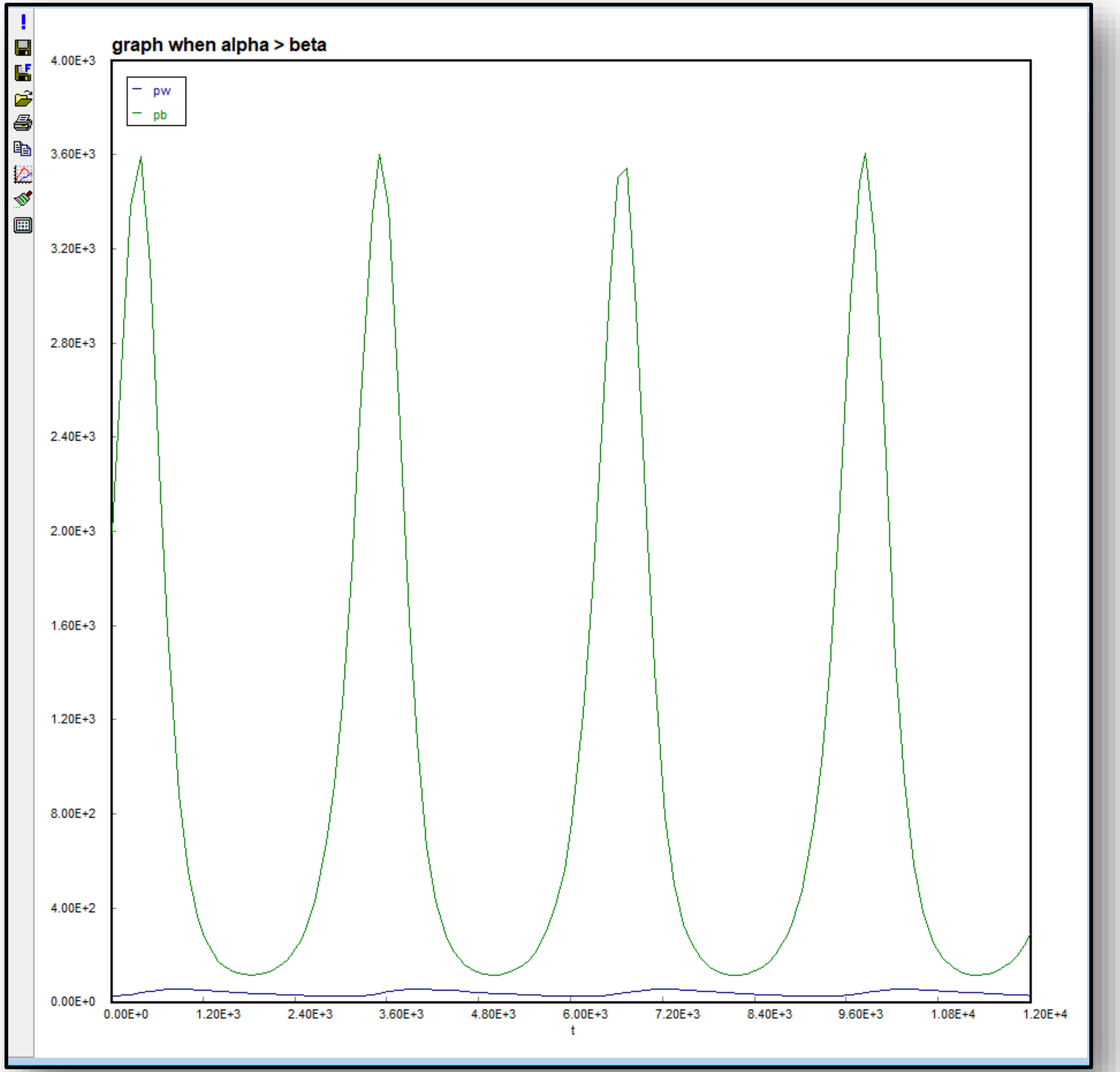
- Where the table below defines each variable.

	A	B	C	D
1	Variables	Description		
2	P(b)	Butterfly Population		
3	P(w)	Wasp Population		
4				
5	α	Proabability of anti-aphrodisiac increase P(b)		
6	β	Proabability of anti-aphrodisiac attracts wasp		
7	k(1)	P(b) Birth Rate		
8	k(2)	Capacity		
9	k(3)	P(b) Death Rate		
10	k(4)	P(w) Natural Death Rate		
11	k(5)	Conversion Efficiency		
12	k(6)	P(w) Birth Rate		

DATA: 1

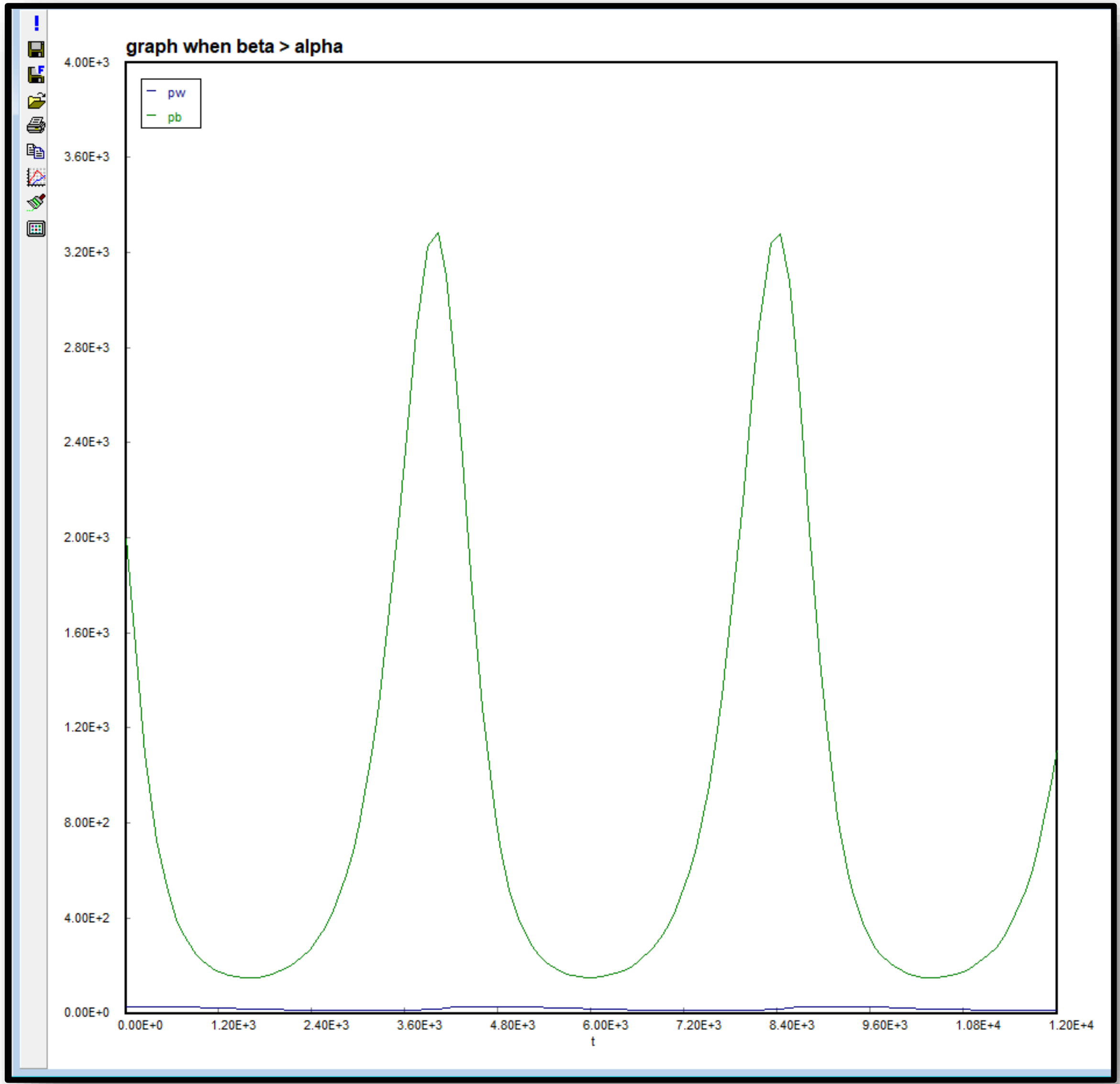

graph when alpha and beta = 1
pw
pb
5.00E+3
4.50E+3
4.00E+3
3.50E+3
3.00E+3
2.50E+3
2.00E+3
1.50E+3
1.00E+3
5.00E+2
0.00E+0
0.00E+0
1.20E+3
2.40E+3
3.60E+3
4.80E+3
6.00E+3
7.20E+3
8.40E+3
9.60E+3
1.08E+4
1.20E+4
t

DATA: 2



graph when alpha > beta
pw
pb
4.00E+3
3.60E+3
3.20E+3
2.80E+3
2.40E+3
2.00E+3
1.60E+3
1.20E+3
8.00E+2
4.00E+2
0.00E+0
0.00E+0
1.20E+3
2.40E+3
3.60E+3
4.80E+3
6.00E+3
7.20E+3
8.40E+3
9.60E+3
1.08E+4
1.20E+4
t

DATA: 3



graph when beta > alpha
pw
pb
4.00E+3
3.60E+3
3.20E+3
2.80E+3
2.40E+3
2.00E+3
1.60E+3
1.20E+3
8.00E+2
4.00E+2
0.00E+0
0.00E+0
1.20E+3
2.40E+3
3.60E+3
4.80E+3
6.00E+3
7.20E+3
8.40E+3
9.60E+3
1.08E+4
1.20E+4
t

ANALYSIS:

- In the a predator-prey relationship, the butterfly population will increase as the wasp population decreases.
- We state that the wasp population is not only dependent on the birth rate, but also relies on k(5), the efficiency of a wasp converting its food, P(b), into offspring, the change in wasp population will begin to increase when the butterfly population is high.
- This interaction creates a cyclic pattern of wasps increasing with more food available (increase in butterfly population) and decreasing as they consume too much food and vice-versa with the butterfly population.

CONCLUSION:

- As mentioned before, we have to make a lot of assumptions for this model to make sense. For example, all of the rates are assumed to be constant in the two equations describing the interaction of the species. Not only that, but also, we assume that the butterfly has only one predator and the predator has only one food source and we assume that more of the species do not enter the ecosystem from elsewhere, neither does the species migrate out of the environment they inhabit. Another thing to consider is that the prey has an unlimited food source. With all of this in mind, the model still shows a plausible representation of interaction, when specifically observing two species of a predator-prey relationship.