SCUDEM IV 2019

Problem C: Chemical Espionage

By

Team Members: Leslie Perez, Olivia Balderas, and Evina Moreno
Coach: Reza Ahangar
Texas A&M University- Kingsville

The large cabbage white butterfly (Pieris brassicae)

Parasitic wasps

1. Assumptions

- 100 female butterflies
- 100 male butterflies
- 100 wasps
- A female butterfly will lay approximately 60 eggs a year
- 70% of female butterfly population will mate
- 28% of mated female butterfly population will be latched on to by a wasp
- Our system can hold up to 10,000 butterflies
- Only 25% of healthy eggs will survive

Why we Made These Assumptions

- The large cabbage white butterfly lays 20-50 eggs two times a year.
- A study done by Nina Fatouros showed that in a population of female butterflies, 28 were latched on to by the neighboring wasp population.
- Because the male butterflies release the anti-aphrodisiac, only 70% of the female population will end up mating.
- Not all the healthy eggs will survive long enough to become a butterfly

2.

Rate of Butterfly Growth

Rate = Birth-Death

Rate of Growth for One Year

Butterfly Eggs Laid

70 Mated Females * 60 Eggs=

4,200 Eggs

Butterfly Eggs Infected with Parasite

28 Latched Female Butterflies * 60 Eggs=

1,680 Eggs

4,200 Eggs- 1,680 Eggs= 2,520 Eggs

2,520 Births – 1,890 Deaths= 630 Butterflies

630 Butterflies / 200 Butterflies = 315% Increase in Population

In our system the population will grow at a rate of 315%

3.

Model

Differential Equation

P= Population
Po = Initial Population (200)
t= Time (years)
k= Rate (3.15)
M= Carrying capacity (10,000 butterflies)

Steps Taken:

$$\frac{dP}{dt} = P\left(\frac{1-k}{m}\right)$$

$$\int \frac{dP}{P\left(1-\frac{P}{M}\right)} = \int k\,dt$$

$$\int \frac{dP}{\left(P-\frac{P^2}{M}\right)} = kt + c$$

$$ln|P| - \ln\left(1-\frac{P}{M}\right) = kt + C$$

$$e^{ln|P|} - e^{\ln\left(1-\frac{P}{M}\right)} = Ce^{kt}$$

$$\frac{P}{1-\left(\frac{P}{M}\right)} = Ce^{kt}$$

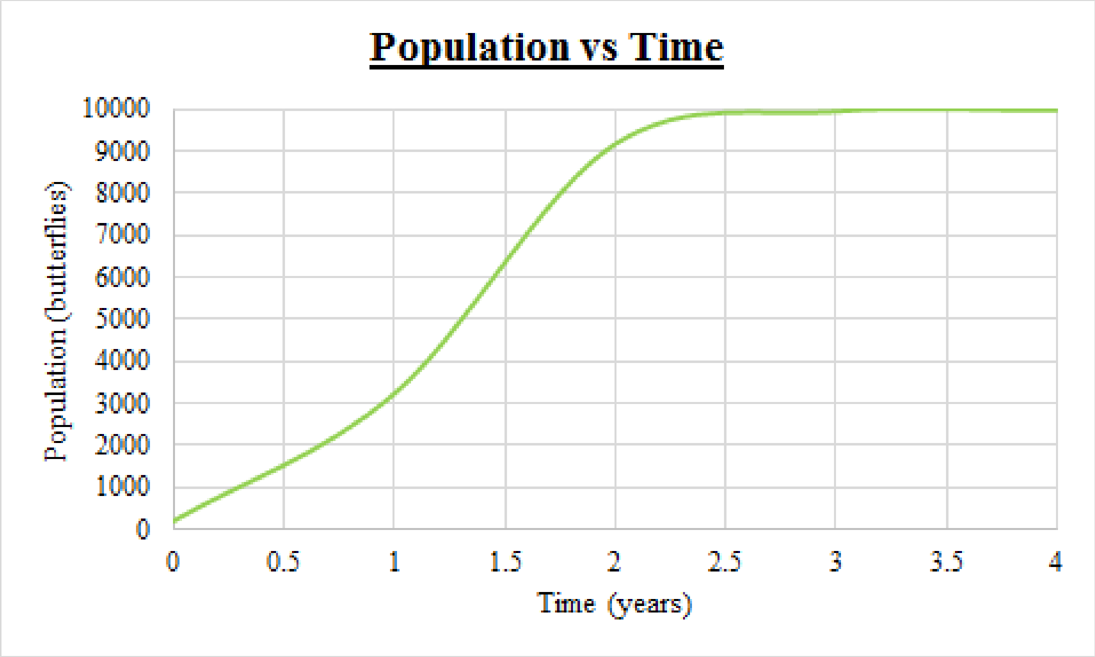
$$P = \frac{MCe^{kt}}{M + Ce^{kt}}$$

$$C = \frac{P_o M}{M - P_o}$$

$$\boldsymbol{P(t) = \frac{MP_o}{P_o + (M - P_o)e^{-kt}}}$$

Population

Time (years)	Population (butterflies)
0	200
1	3226
2	9174
3	9961



Population vs Time
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Population (butterflies)
0
0.5
1
1.5
2
2.5
3
3.5
4
Time (years)

4.

Conclusion

Long Term Affects

Our model contains many flaws, including disregarding the death rate of the grown butterfly population. We also did not take into account a fluctuation in all three populations of insects. Based off our findings, we can see that the population of butterflies will reach its carrying capacity in 2-3 years . However this is most likely incorrect, as the ratio between all three insects will most likely change during this time period and affect the results.