Chemical Espionage

A MODEL OF BUTTERFLY AND WASP INTERACTIONS USING DIFFERENTIAL EQUATIONS

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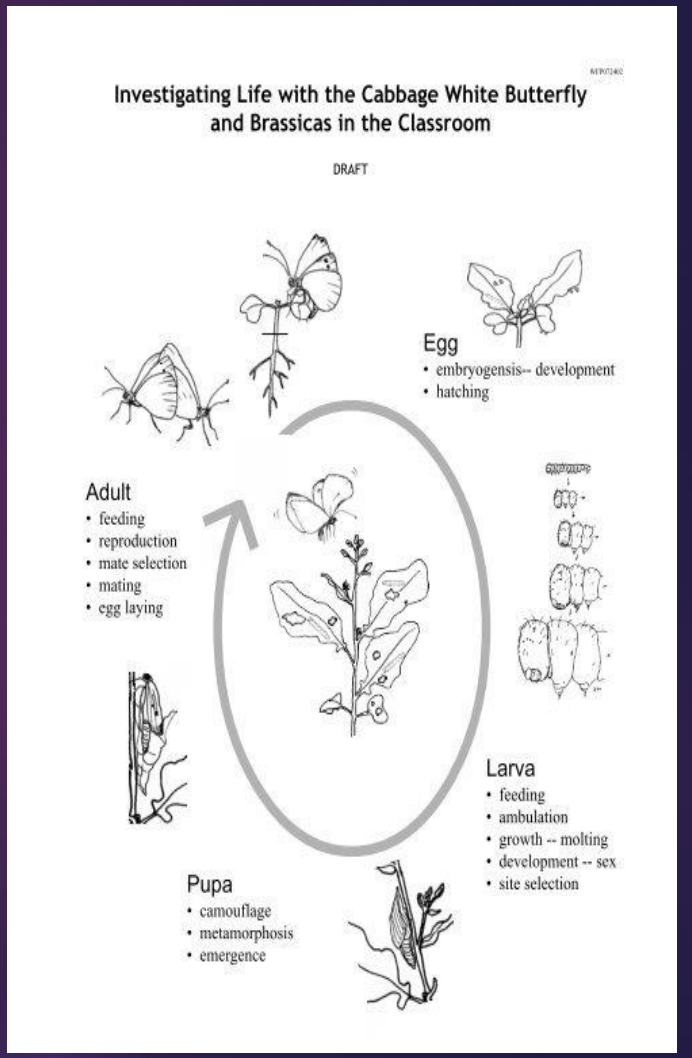

The Problem

The female Large White Cabbage Butterfly uses aphrodisiacs to attract the males for mating. The male releases anti-aphrodisiacs to deter other males. However, this anti-aphrodisiacs attracts parasitic wasps. These wasp parasites the eggs and kill the larvae inside. We wanted to model this interaction to see how much anti-aphrodisiacs the butterflies need to produces for both of these species to coexist.

Parameters

Parameter	Description	Value	Assumptions
k	Carrying capacity	Varies	Varies with equilibrium
α	Birth rate of butterflies	25	Each butterfly lays 20-50 eggs
μ	Death rate of butterflies	20	High death rate since they are preyed upon frequently
ρ	Amount of anti-aphrodisiac	Varies	
σ	Death rate of wasps	12	Natural Death Rate
W	Wasp population		Measured in tens
B	Butterflies population		Measured on tens

Differential Equation Model

$$B' = \alpha B\left(1 - \frac{B}{k}\right) - \mu B - \rho BW$$

$$W' = \rho WB - \sigma W$$

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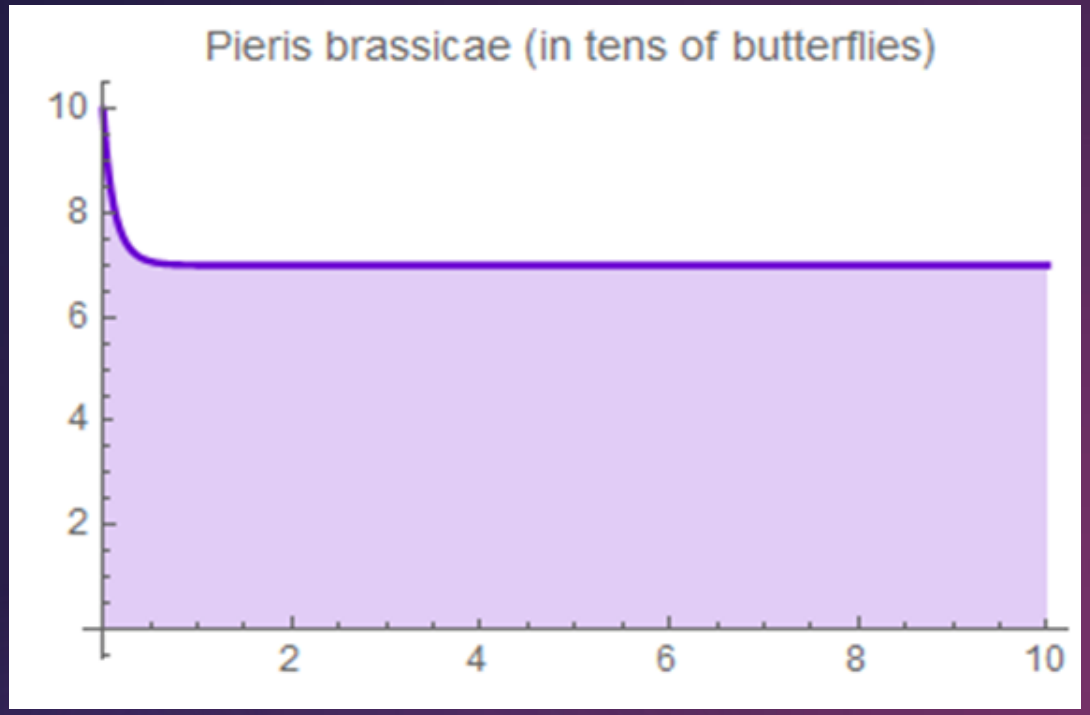
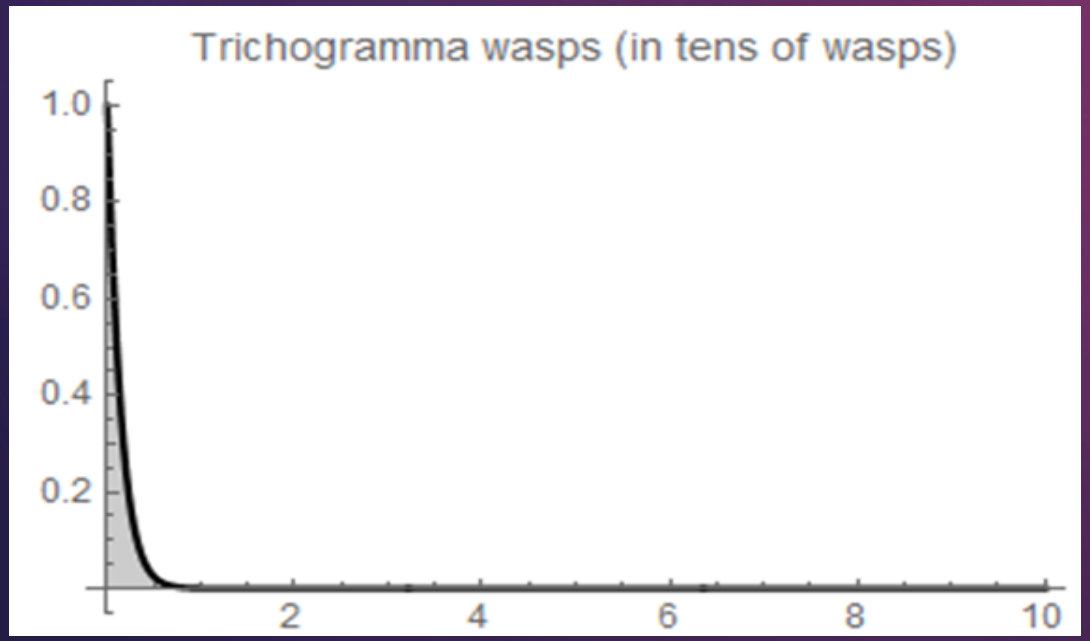
Explanation of the Differential Equation Model

Yellow: Rate at which the butterfly population is increasing.

Green: Rate at which butterflies/wasps die within their population.

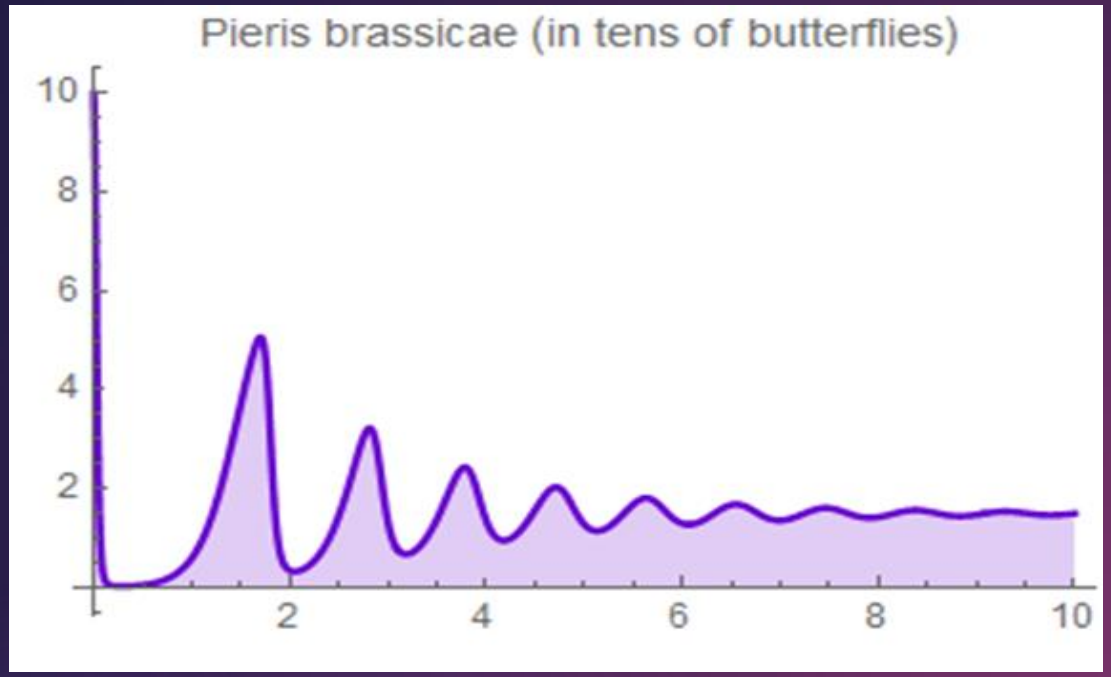
Pink: Interaction rate between the anti-aphrodisiacs, the butterfly population, and the wasp population.

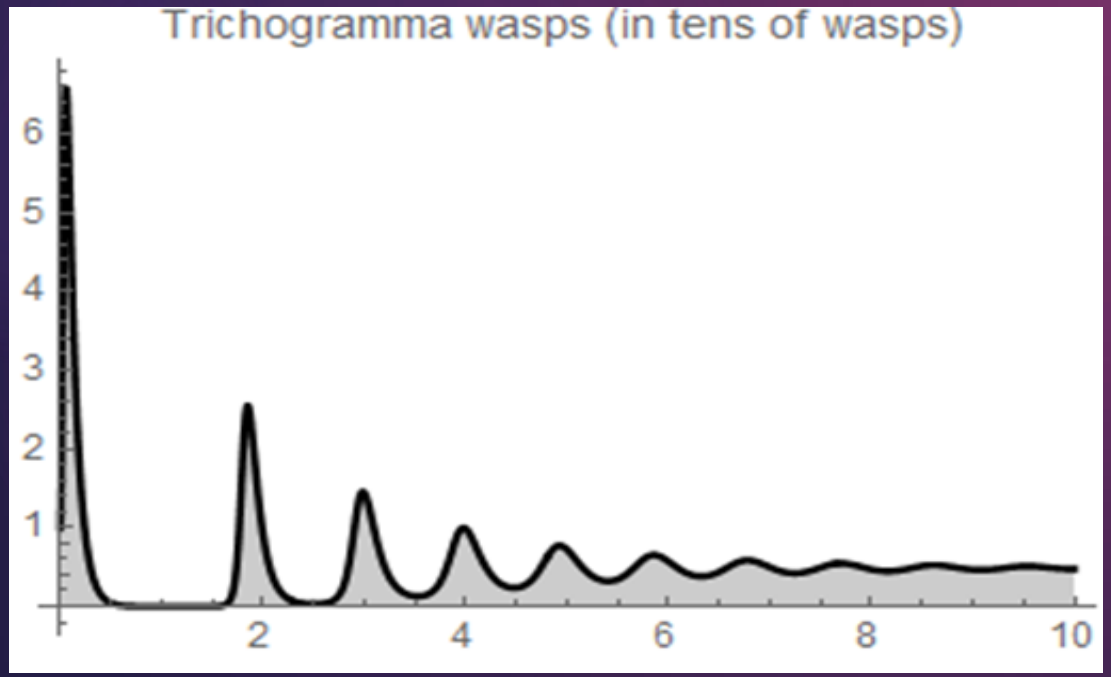




Low Level of Anti-Aphrodisiacs

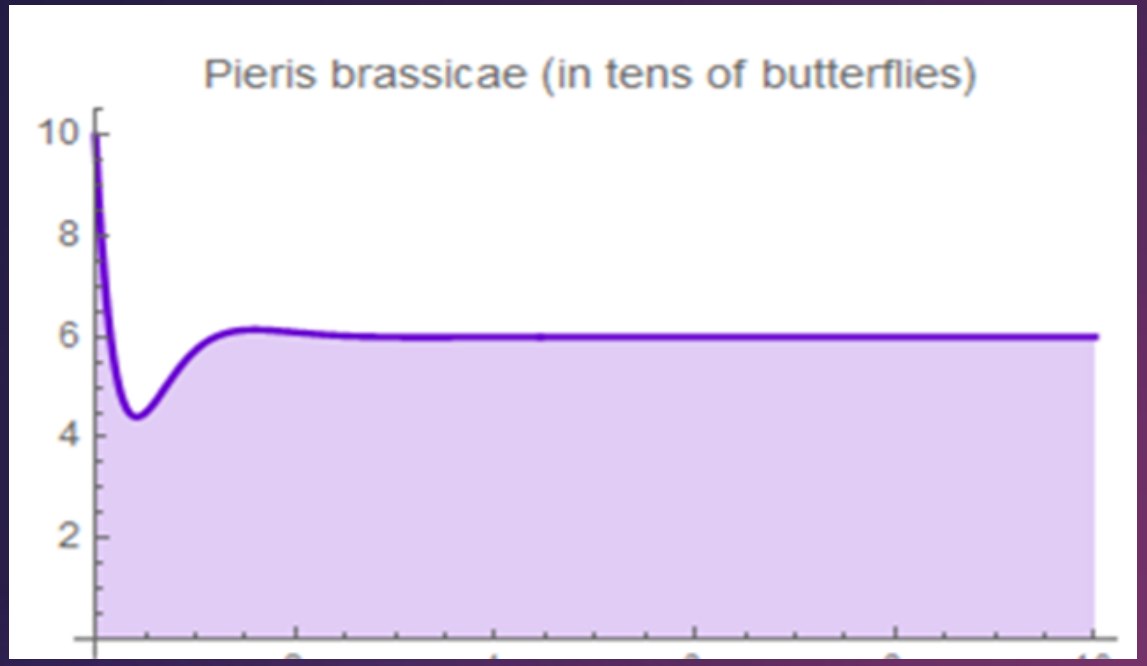
- Wasps aren't able to find enough eggs to parasitize
- Butterfly populations grows to carrying capacity without any predators to hunt them.

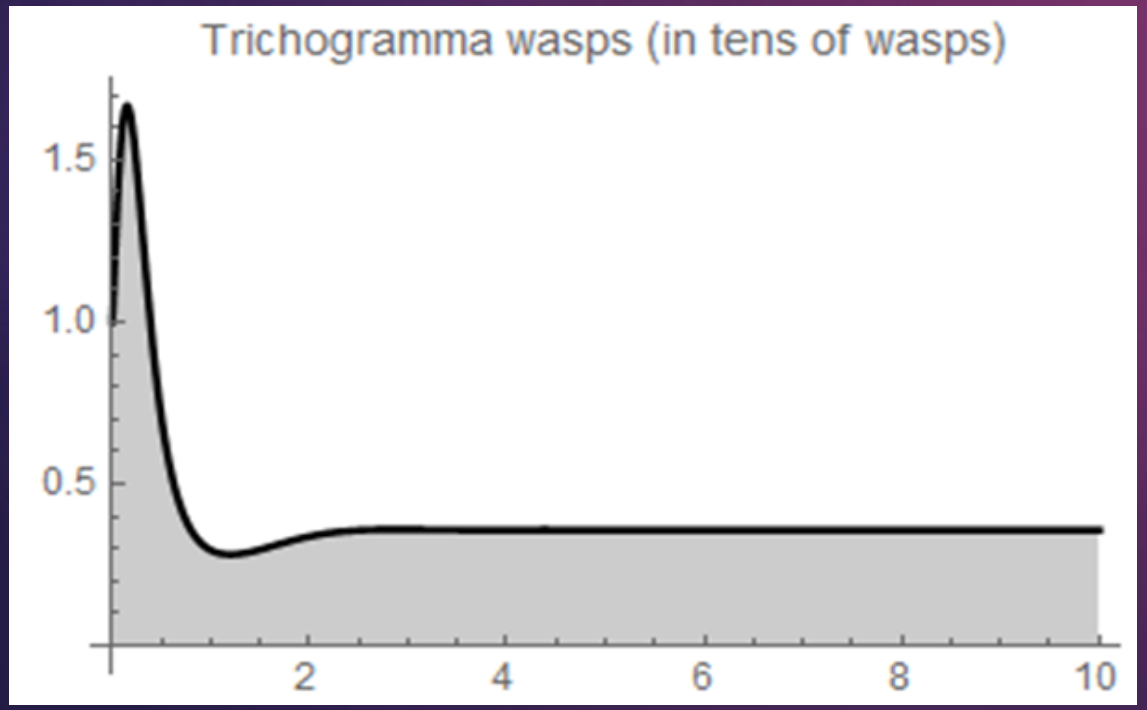




High Level of Anti-Aphrodisiacs

Coexistence present, but small variations could drive population extinct.





Healthy Levels of Anti-Aphrodisiacs

Coexistence present at stable amounts for both species

Conclusions and Future Work

We found that the amount of anti-aphrodisiacs to achieve coexistence is 2 millimeters.
This result also agrees with the research we conducted for this project which also stated that males produces 2 millimeters on average.

My future work includes:
Including more predators in this model like birds.
Include equations on male butterflies and eggs.
Add in more variables to make the model more accurate such as temperature/climate.