Chemical Espionage

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Parameters

Parameter	Description	Value	Assumptions
k	Carrying capacity	Varies	Varies with equilibrium
α	Birthrate 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-aphordias	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

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

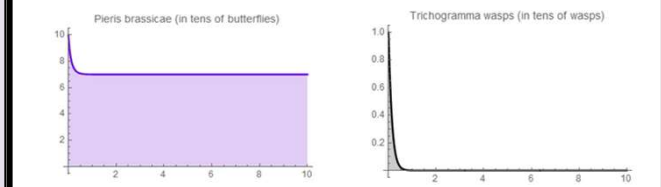
Equilibrium

Equilibrium	Stability conditions
$W = 0 \quad B = 0$	$0 < \alpha < \mu$
$B = \frac{k(\alpha - \mu)}{\alpha} \quad W = 0$	$0 < k < \frac{\alpha\sigma}{\alpha\rho - \mu\rho}$
$B = \frac{\sigma}{\rho} \quad W = -\frac{-k\alpha\rho + k\mu\rho + \alpha\sigma}{k\rho^2}$	Always stable when it exists $k > \frac{\alpha\sigma}{\alpha\rho - \mu\rho}$

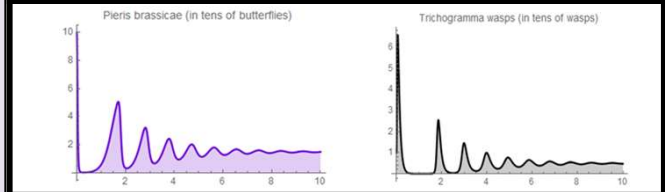
The Problem

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.

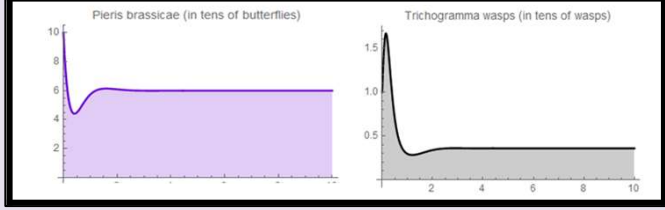
Results



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 levels of anti-aphrodisiacs
- Coexistence but small variations could drive population extinct.



Healthy levels of anti-aphrodisiacs
- Coexistence 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.

Future Work

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.