Chemical Espionage

By Shawn Abraham, Alex Castro Chavez, and Christopher Mabey

Statement

- How does one model the balance between the interactions of the male and female butterflies, specifically the *P. brassicae*, and the parasitic wasps?
- Initial Reactions – We knew making plenty of assumptions was key to having a model that would work
- (Every time a model is introduced assumptions must be made, most common one is air resistance, assume incompressible fluid, makes things easier)

Flow of Process

- Female releases aphrodisiac to attract males
- Male responds to the signal and mates,
  - Then coats eggs with anti-aphrodisiac do dissuade other males from mating
- Anti-aphrodisiac is both harmful and beneficial to male and female
  - Increases chance to find optimal nesting location and decreases chance for other males to mate
  - Increases chance that a wasp will parasitize eggs

Outcomes

- Offspring is produced, keeps the population of the butterflies alive

- Larvae is eaten by wasps, keeps the population of the two specific species of wasps alive

Assumptions

- Pheromones dictate interactions
  - Concentration varies w.r.t. predator and prey population
- Dynamics in closed volume (nothing enters or leaves once started)
  - Spatially independent
- Wasps and Butterfly interact with each other only

Model

- $\frac{dB}{dt} = B(g - k_1 CW)$
- $\frac{dW}{dt} = W(k_2 CB - d)$
- $C = k_b \frac{1}{B} - k_w \frac{1}{W}$

- B: Butterfly population density
- W: Wasp population density
- g: Butterfly population growth rate
- d: Wasp death rate
- $k_1 C$: predation rate factor
- $k_2 C$: predator success factor
- C: Pheromone concentration

Adjusted Model with super predator

- $\frac{dB}{dt} = B\left(g\ -\ r_{p/1}W - r_{p/2}P\right)$
- $\frac{dW}{dt} = W\left(r_{s/1}B\ - r_{p/3}P - d_w\right)$
- $\frac{dP}{dt} = P\left(r_{s/2}B + r_{s/3}W - d_p\right)$
- $C = k_b\frac{1}{B}\ -\ k_w\frac{1}{W}$

- $r_{p/1}$: Wasp-Butterfly Predation factor
- $r_{p/2}$: Predator-Butterfly Predation factor
- $r_{p/3}$: Predator-Wasp Predation factor
- $r_{s/1}$: Wasp-Butterfly food source factor
- $r_{s/2}$: Predator-Butterfly food source factor
- $r_{s/3}$: Predator-wasp food source factor

Conclusion

- What’s likely to happen in the future?
- Based upon our equation, we could assume that at one point there will be an increase of butterflies and another moment of time there will be an increase of wasps(assuming no outside interaction). Why? There must be a fluctuation. If species continues to increase, they will be overpopulated, ultimately killing themselves, or overspreading.