EXECUTIVE SUMMARY

Problem C: Chemical Espionage

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Problem Statement:

Determine tradeoffs and balance between the two competing interests of male Pieris Brassicae and parasitic wasps. Determine the best balance for the system and predict what is likely to happen in the long run.

Introduction:

It is difficult for female butterflies to attract mates. In order to counteract this, they release a chemical signal to attract males. In return, the male butterfly then injects a chemical signal, anti-aphrodisiac, to dissuade other males. Anti-aphrodisiac allows a greater chance of males to fertilize females and for the female to find an advantageous place to lay their eggs. However, the chemical released by the male is tracked by parasitic wasps. The wasps are able to track the female and lay their eggs into the butterflies' eggs.

Assumptions:

- Once a male fertilizes the female, they inject anti-aphrodisiacs immediately, not allowing other males to interfere.
- 100% success rate of parasitism
- All butterfly eggs will survive on their own, unless preyed upon by larvae
- 35 eggs per butterfly clutch
- 8 eggs per wasp clutch
- The two identified wasp larvae are the species aiming to eat the *Pieris brassica's* eggs.
- "Most likely" the wasp larvae's eggs will eat the butterflies' eggs.
- The wasp larvae detect the anti-aphrodisiacs (chemical signals) when a male produces them to seduce other males.
- Wasps eggs will "arise" before butterfly eggs or they hatch at the same time, but wasp larvae are more dominant than butterfly larvae.
- Larvae will eat butterfly eggs and impinge on their population growth.
- When wasps are "more likely" to consume butterfly eggs, we assume it means between 50% to 99.9%.

Analysis:

$$\frac{dP}{dt} = P_o + Fx - Ly$$

P= population

$P_o = initial\ population$

F= # of females that can reproduce

X= # of eggs per clutch (butterfly)

Y= # of eggs per clutch (wasp)

L= # of wasps

<u>Limitations:</u>

The number of eggs laid per each clutch are variant, so the average size was taken. We also did not take into consideration of the life expectancy or deaths of butterflies once they survived the hatching stage.

<u>Conclusion:</u>

The tradeoffs of this system are that both male competition and parasitic larvae dwindle the population growth of the butterfly species. While the clutch size of the butterfly is larger than the clutch size of the parasites, the number of butterflies that are females are half the population of the eggs that survive (if we assume a 1:1 ratio of male to female gender). While not only the population grows slower due to parasites, the number of wasps increase as well which will further endanger the population. At the same time, the strength of the chemicals and their success rate must be taken into consideration as well. We have not solved the differential equation, but we did take into account all possible variables. Our theory is that as time progresses, the population of wasps will overcome the butterfly population, therefore making the butterfly species extinct

We believe our equation simulates the population growth of P. Brassicae and parasitic wasps located in the same environment. We believe that our equation could be further developed if we took into consideration the life span of the butterflies and the success rate of the parasites. Many assumptions were made for simplification. A deeper understanding of differential equations from the group members would've greatly enhanced the performance of the project.

<u>References:</u>

[1] "Chemical espionage on species-specific butterfly anti-aphrodisiacs by hitchhiking Trichogramma wasps, " Martinus E. Huigens, Jozef B. Woelke, Foteini G. Pashalidou, T. Bukovinszky, Hans M. Smid, and Nina E. Fatouros. Behavioral Ecology. Volume 21, Issue 3, MayJune 2010, Pages 470–478, 11 February 2010. https://doi.org/10.1093/beheco/arq007 .