Chemical Espionage Executive Summary

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Overview

Our group was tasked with modeling the interactions between female and male Large White Cabbage Butterflies and parasitic wasps. The model we chose to use modeled the overall White Cabbage Butterfly population in a population growth and decay equation. We will discuss the interactions between male and female White Cabbage Butterflies, and the interactions of parasitic wasps and White Cabbage Butterflies.

Part 1

For our model we assumed that for every 1 female butterfly, there would be 1 male butterfly to mate with. We were able to assume this because as the female gives off her signal to attract the males, a male butterfly will give off an anti-aphrodisiac to dissuade the other male butterflies. Since there is a 1 to 1 proportion of male to female butterflies, we can use the total population as a whole. When each female finds a mate, they will lay 20-50 eggs in cabbage plants. The parasitic wasps leave their larvae on the female butterfly which causes the eggs to be covered in the wasp larva. Ultimately the larvae will kill off some of the fertilized eggs which we can subtract off of the total population of Large White Cabbage Butterflies. Our equation we created was $dp/dt = kp - y$ where dp/dt is the change in butterfly population over time, k is the number of fertilized eggs, p is the butterfly population, and y is the amount of fertilized eggs killed by the parasitic wasps' larvae.

Part 2

The benefits of this model is that the female butterflies will each have one male partner because the male gives off the anti-aphrodisiac keeping the other males away. Since the female does not have to mate with more than one male, she can lay her eggs in the most advantageous spots. The tradeoff to having one mate is the anti-aphrodisiac attracting the parasitic wasps. Since the parasitic wasps are attracted, they leave larvae, causing a decrease in the amount of fertilized eggs to survive. The male butterflies will be more likely to fertilize the eggs if they give off the anti-aphrodisiac.

Part 3

With our model, the butterfly population will greatly increase because the amount of eggs that are killed by the parasitic wasps is not enough to decrease the total butterfly population. The model is not completely accurate because the total population increases too large, too fast. It is somewhat accurate because it does show that the population is increasing as is the population of these butterflies in real life.

Here is the solved differential equation model.

$$dP/dt = 20P - 7$$

$$1/(20P - 7)\, dP = 1\, dt$$

$$\int 1/(20P - 7)\, dP = \int 1\, dt$$

$$ln|20P - 7| = t + c$$

$$c = 7$$

$$20P = e^{20t} + 7$$

$$P = e^{20t} + 7/(20)$$

References

Behavioral Ecology, Volume 21, Issue 3, May-June 2010, Pages 470–478, https://doi.org/10.1093/beheco/arq007

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