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Problem C: Chemical Espionage

It can be difficult for some insects to find mates. One common way for a female to attract a male is to use chemical signals. One problem with this approach is that this signaling can attract many males, and in response the males often use chemical signals, called anti-aphrodisiacs, that are used to either mask or dissuade other males.

An example of this can be found in the large cabbage white butterfly *Pieris brassicae*. Unfortunately for the butterflies, the chemical signals can be exploited by parasitic wasps. Two species of wasps have been identified that can detect the anti-aphrodisiacs, and when a female butterfly has the chemical signal the wasps are more likely to follow the butterfly and lay their own eggs in the butterflies' eggs.

These interactions introduce two competing pressures on the butterfly population. For the male butterflies the anti-aphrodisiacs make it more likely for them to fertilize eggs. For the female butterflies the anti-aphrodisiacs make it less likely to be bothered by more males, and the females can focus on placing their eggs in the most advantageous place. On the other hand the anti-aphrodisiacs make it more likely these eggs will be eaten by the wasp larvae.

One question that arises is to determine the trade-offs and balance between the two competing interests. To do so develop a mathematical model for the interactions of the male and female *P. brassicae* as well as the parasitic wasps. What is the best balance for this system and what is likely to happen in the long run?

References

[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, May-June 2010, Pages 470–478, 11 February 2010. https://doi.org/10.1093/beheco/arq007 .