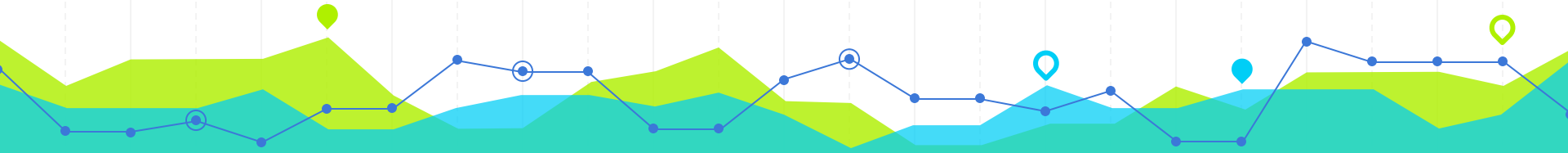
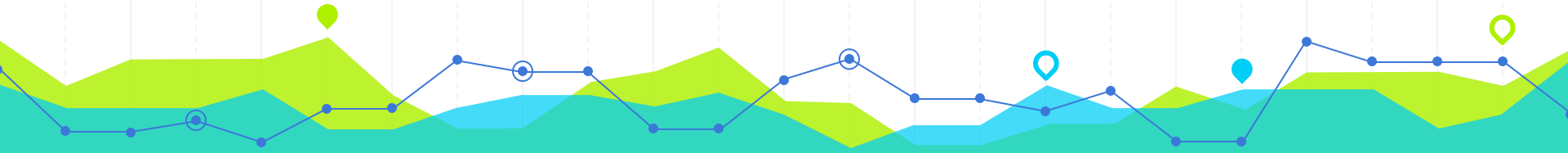


# MODELING CHEMICAL ESPIONAGE IN BUTTERFLIES AND WASPS

Coe College Group 02



# The Problem

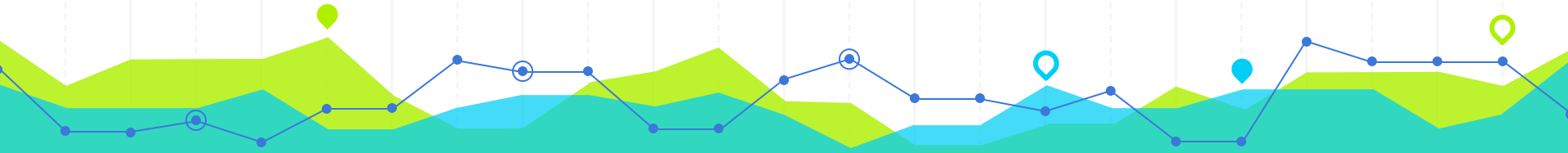
1

What are we trying to model?

# THE BUTTERFLY AND THE WASPS

*Pieris brassicae* are butterflies that often are pests devastating crops of the genus *Brassica*, such as cabbage and cauliflower. Wasps such as *Trichogramma brassicae and Trichogramma evanescens* are introduced to limit populations

Male *Pieris brassicae* release an anti-aphrodisiac on the females after mating, but this signals the wasps to begin parasitic behavior



# Simplifying Assumptions

2

What are the limitations of this model?

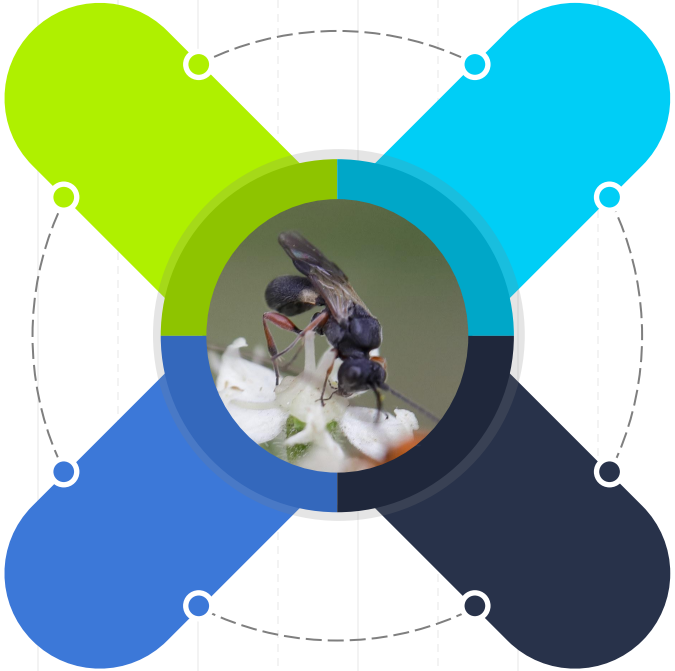
# KEY ASSUMPTIONS

## Wasps Are One Population

*Trichogramma brassicae* and *Trichogramma evanescens* can be modeled as one population.

## Parasitism Rate Independent

The parasitism rate is not dependent upon the population of the wasps



## Parasitism is Innate

Wasps mounting anti-aphrodisiac-affected butterflies is an innate behavior and not tied to long term memory from previous experiences, as the study suggests.

## Obligate Parasitism

The wasps are obligate parasites, that is, they must replace *Pieris brassicae* eggs in order to reproduce.

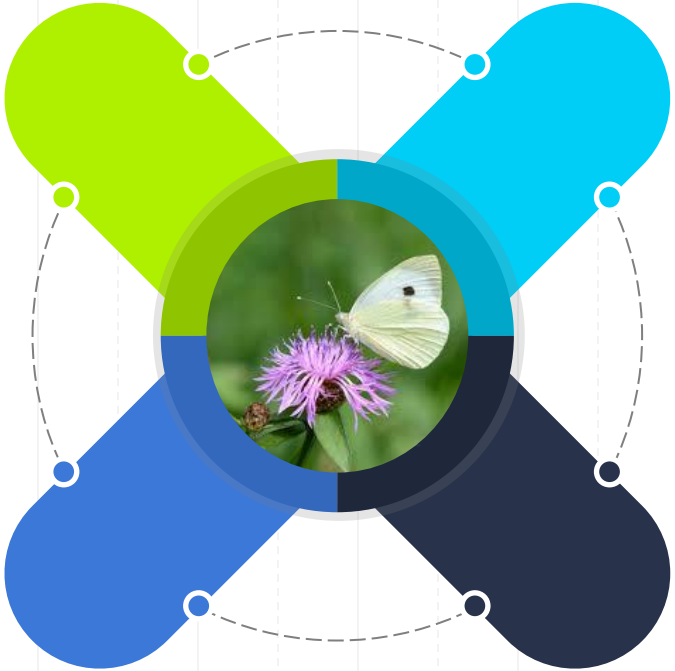
# KEY ASSUMPTIONS CONT.

## Sex Ratio

*There is an equal amount of male and female butterflies in the starting population, and the birth rate is 1:1*

## Egg Replacement

The eggs of *Pieris brassicaeare* replaced by wasp eggs in a 1:1 ratio



## Anti-Aphrodisiac Necessary

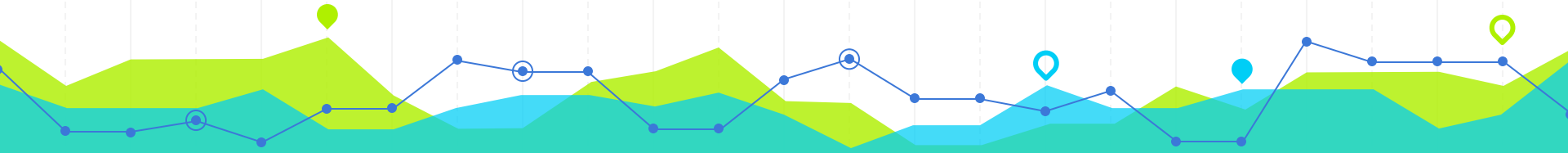
The anti-aphrodisiac is required for a successful mating inPieris brassicaeand a successful parasitism by either wasp

## Constants

Both birth rate and natural death rate are constant throughout the year and each female of all three species will lay eggs once through its life-cycle

# KEY ASSUMPTIONS CONT.

**Most importantly**, the populations of each species are not affected by extraneous factors other than natural birth/death and symbiotic relationship (in this case, parasitism) between the species.



# The Model

3

How do the parameters fit together?

$$\frac{db}{dt} = -d_b b + (a_1 - a_2) e s_b b (L_b - b)$$

$$\frac{dw}{dt} = -d_w w + a_2 e s_w b (L_w - w)$$

Butterfly Death Rate

Successful Pairing Factor from Anti-Aphrodisiac

Butterfly Maturity Success Rate

Butterfly Carrying Capacity

$$\frac{db}{dt} = -d_b b + (a_1 - a_2) e s_b b (L_b - b)$$

Parasitism Rate from Anti-Aphrodisiac

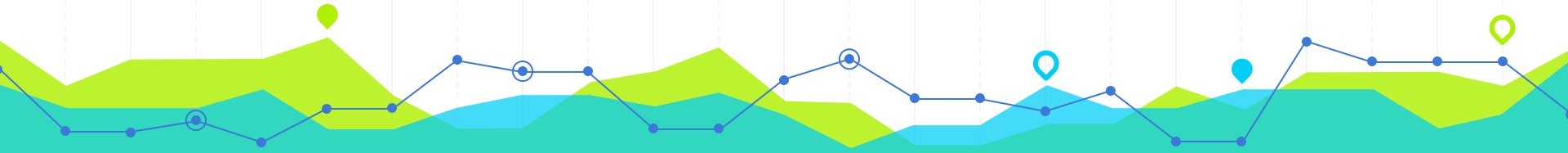
Number of Eggs Laid

$$\frac{dw}{dt} = -d_w w + a_2 e s_w b (L_w - w)$$

Wasp Death Rate

Wasp Maturity Success Rate

Wasp Carrying Capacity



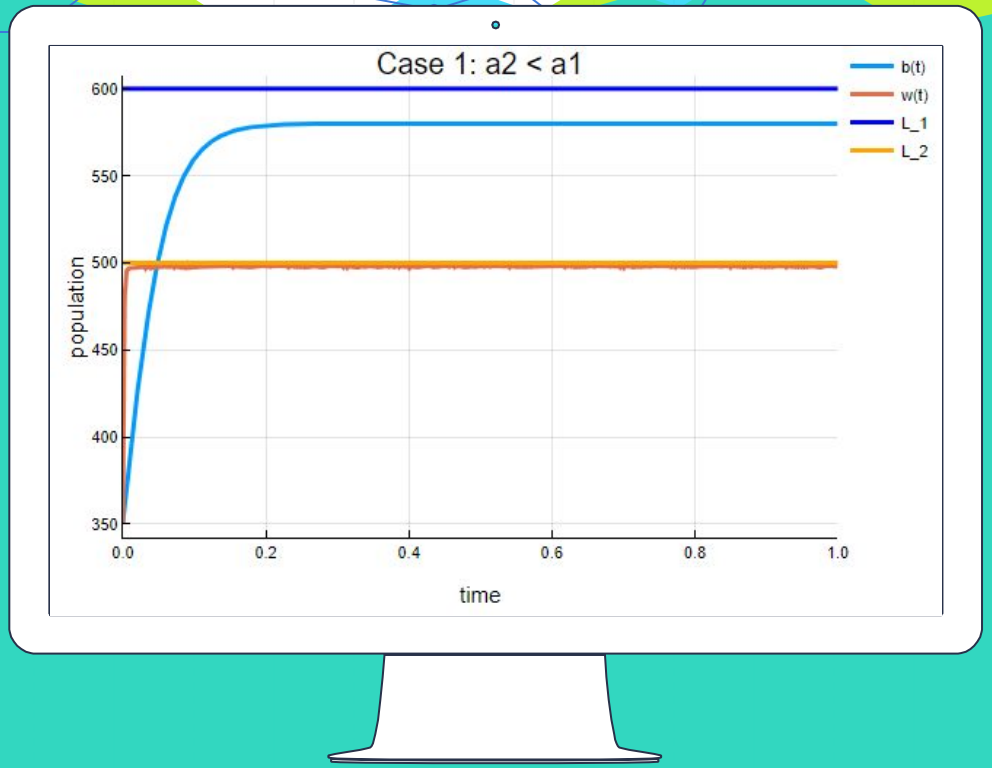
# Output

4

What does the model say about our system?

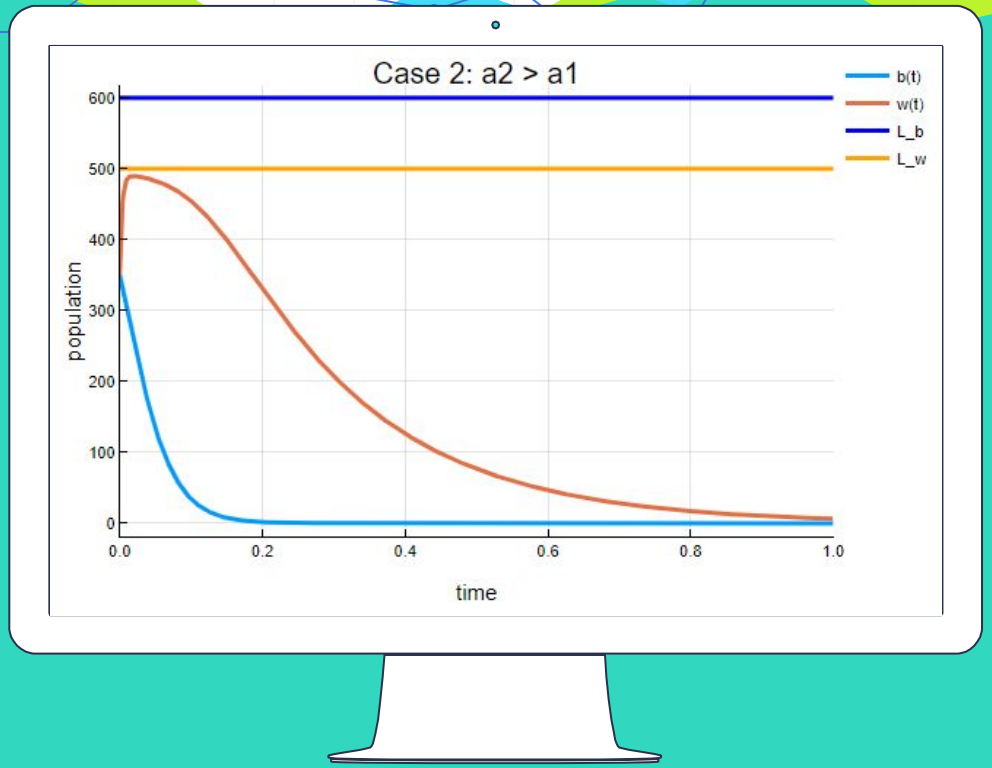
## QUALITATIVE CASE 1

In the first case, the benefits of the anti-aphrodisiac outweigh the costs to *Pieris brassicae*, and thus both butterflies and wasps reach a sustained population close to their carrying capacity.



## QUALITATIVE CASE 2

In the second case, the costs of the anti-aphrodisiac limit the population of *Pieris brassicae*, which then limits the population of the wasps, as they are obligate parasites



# WHAT DO THESE QUALITATIVE CASES REPRESENT?

**Most Balanced**

The first system allows both butterflies and wasps to reach a population near their carrying capacities,and thus is the more balanced option.

**Most Likely**

The number of successful pairings is limited to 0.5 times the population ($a1 \leq 0.5$), but the parasitism rates of these wasps has been reported at 50%−100% ($a2 = 0.5-1.0$), so the second case is more likely

# THANKS!

## Any questions?

# CREDITS

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# REFERENCES


- "*Pieris Brassicae* (Large Cabbage White)." CABI, 11 Oct. 2014, www.cabi.org/isc/datasheet/41157.
- Smith, Sandy M. (1996). "Biological control with *Trichogramma*: advances, successes, and potential of their use". Annual Review of Entomology. doi:10.1146/annurev.ento.41.1.375.
- Martinus E. Huigens, Jozef B. Woelke, Foteini G. Pashalidou, T. Bukovinszky, Hans M. Smid, Nina E. Fatouros, Chemical espionage on species-specific butterfly anti-aphrodisiacs by hitchhiking *Trichogramma* wasps, Behavioral Ecology, Volume 21, Issue 3, May-June 2010, Pages 470–478, https://doi.org/10.1093/beheco/arq007
- Van Heiningen TG, Pak GA, Hassan SA, van Lenteren JC. 1985. Four year's results of experimental releases of *Trichogramma* egg parasites against lepidopteran pests in cabbage. MedFac Landbouww Rijksu-niv Gent. 50:379–388.