

Vertical Transmission SIR Model with Vital Dynamics

Many social species exhibit warfare where members of one group battles with one or more opposing groups. This behavior is seen in many different species of insects such as ants as well chimpanzees and, of course, humans. In this project, you will develop a basic model that describes the population dynamics of two warring populations when the war lasts longer than a single generation. Which side wins? Do both populations kill each other off? Can the war last perpetually?

Background

Certain social species can exhibit organized violent conflicts that, depending on your definition, could be called a “war”. Examples of these species include types of ants, bees, hornets, and other social insects as well as primates such as chimpanzees and, obviously, humans. An historical example of chimpanzee warfare was the Gombe Chimpanzee War observed by Jane Goodall. For this project, you will study the effect a long-time scale “war” between two species or groups within a single species on their population sizes.

Some Model Requirements

- Your model will consist of the population of two or more warring factions.
- In isolation (no war), each population will behave logistically with different birth rates and carrying capacities.
- During the war, each side will suffer casualties that could be a function of their own population and their opponents population.
- There are many different casualty functions that you can explore.
- One casualty function is that the number of casualties suffered by side A is proportional to the population of side B independent of the size of side A. This would model the ability of side B to inflict increasing casualties through increasing numbers. An example might be a large-scale war with bombs where a single individual can inflict large number of casualties.
- Another casualty function is that the number of casualties suffered by side A is proportional to the population of side B and of side A. Here, a single individual from side B can only inflict casualties on a number proportional to the size of A. An example might be age of sail combat on the high seas where individual ships had one-on-one engagements.
- You can choose other casualty functions as you see fit including other effects such as limitations as the numbers increase (battlefield is only so large so troops are held in reserve), etc.

Some Questions to Answer

- How do the populations behave when they are not at war?
- What happens if only one side attacks the other (side B inflicts casualties on side A but not vice-versa)? Can one side wipe out the other side?
- What happens during a “war” where both sides inflict casualties on each other? Under what conditions would each side win? Can the war continue forever or does one side completely destroy the other side?
- How does the choice of casualty functions affect the predictions of the model?