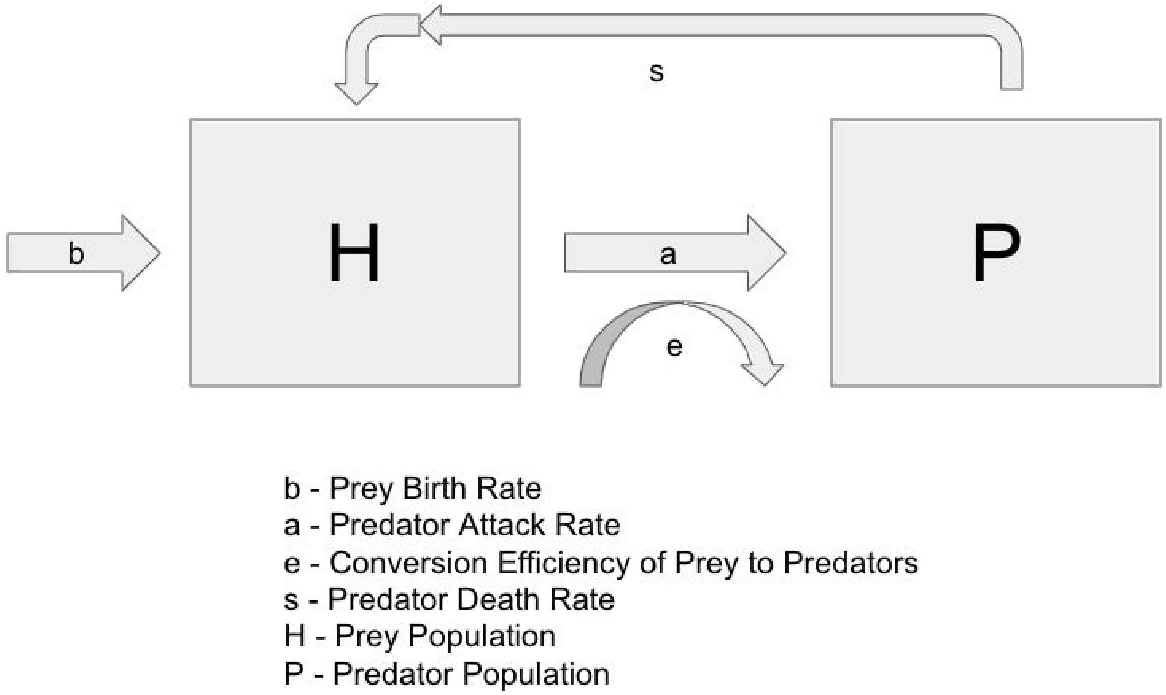
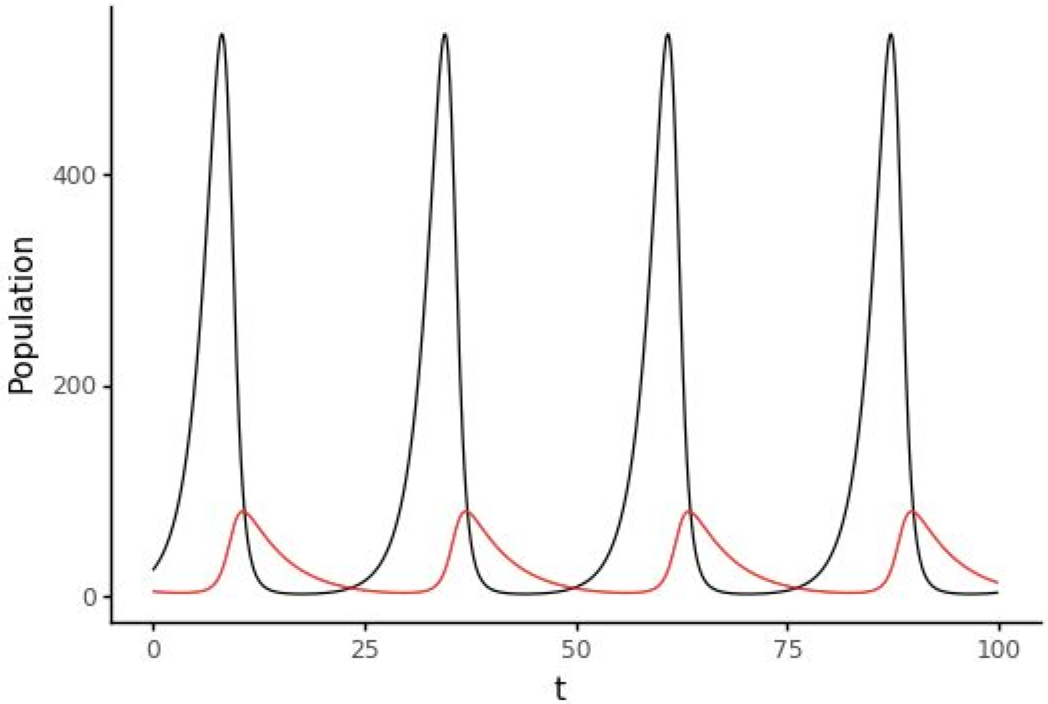
Lotka Volterra

Conceptual Model



Initial Plot

Note that predator population appears in red, and prey population in black

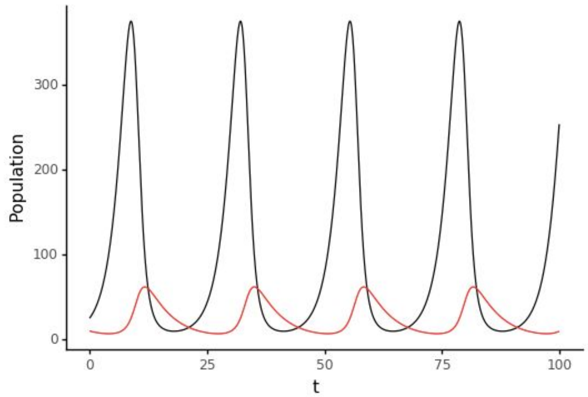


<ggplot: (7532182077)>
Original Parameters

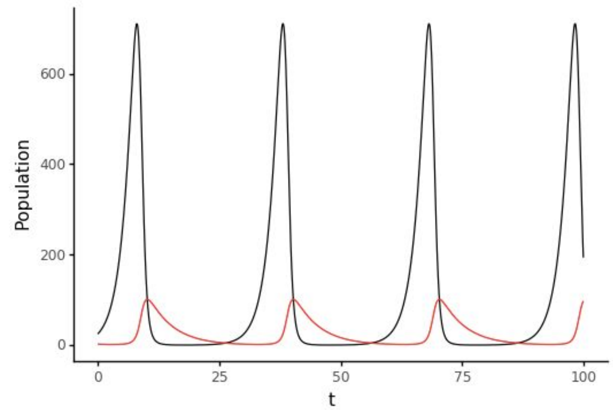
This image represents the Lotka-Volterra simulation run with the original parameters: b=0.5, a=0.02, e=0.1, s=0.2, H_0=25, P_0=5. Predator-prey cycle length sits at roughly 25 units of time.

The Role of Each Parameter

<u>Predator Population, P</u>



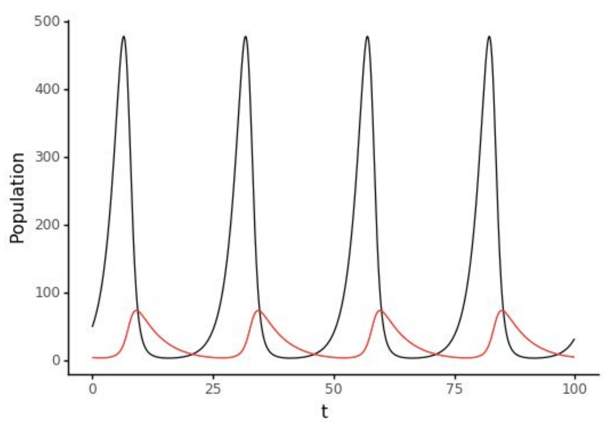
<ggplot: (282382573)>
P Doubled



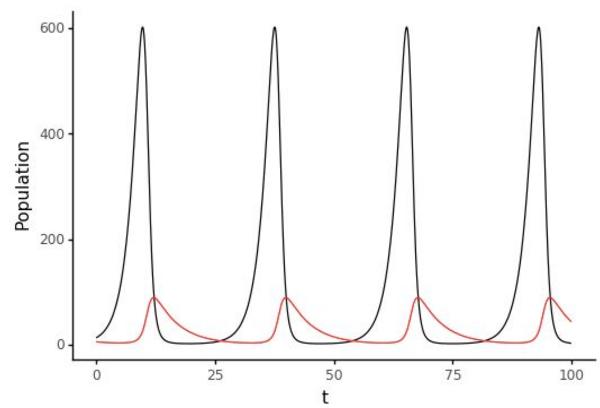
<ggplot: (7532430385)>
P Halved

These two images represent the effect of doubling and halving the predator population P, respectively. Doubling the initial predator population shortens the length of the predator-prey cycle, while halving it increases the length of the cycle. Prey population appears to be directly linearly affected by predator population, as the prey population reaches just under 400 with predator attack rate doubled, and just under 700 with predator attack rate halved. ***

<u>Prey Population, H</u>



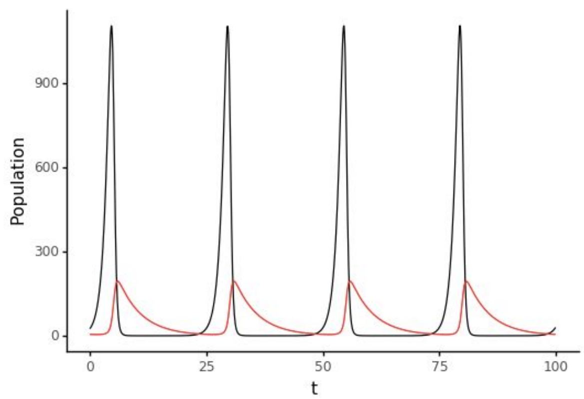
<ggplot: (7532028145)>
H Doubled



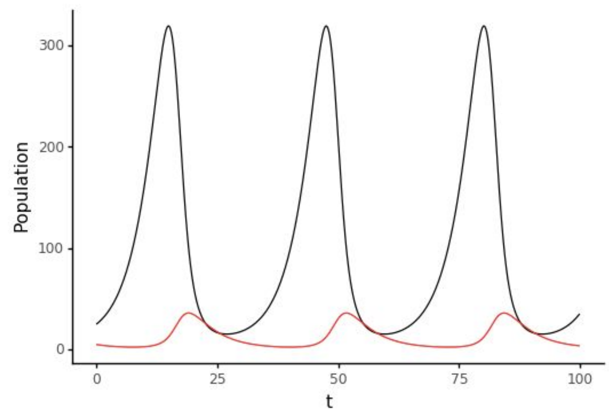
<ggplot: (7532389117)>
H Halved

The above two images represent the effect of doubling and halving prey population H, respectively. Doubling the prey population H shortens the predator-prey cycle marginally, while halving it appears to lengthen the predator-prey cycle marginally. Interestingly, halving initial prey population increases their maximum population.

Prey Birth Rate, b



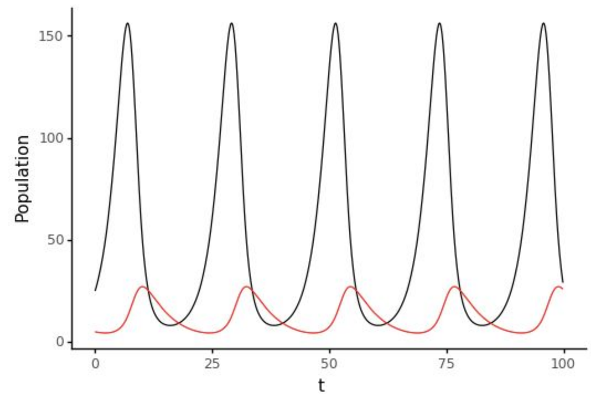
<ggplot: (282375545)>
b Doubled



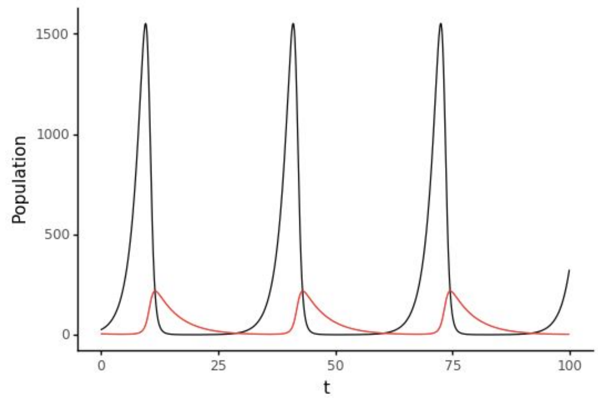
<ggplot: (7532432285)>
b Halved

These two images represent the effects of doubling and halving prey birth rate, b. Doubling prey birth rate leads to a much more significant prey population of nearly 1200, and halving it leads to a population just over 300. The length of the predator-prey cycle is slightly decreased when b is doubled, and increased when b is halved. The shape of the curve is drastically affected by b. Doubling b leads to sharp increases and decreases in population, and halving b leads to relatively smoother increases and decreases. The length of time at which the population remains at its maximum and minimum is also noteworthy. For an increased b, the population remains at its maximum for a short time, and remains at minimum, which appears to be zero on the graph, for an extended length of time. For a decreased b, the maximum is maintained for a relatively extended period of time, and the population never reaches a near-zero point. The maximum value for population is significantly increased by doubling b, and significantly decreased by halving b.

Predator Attack Rate, a



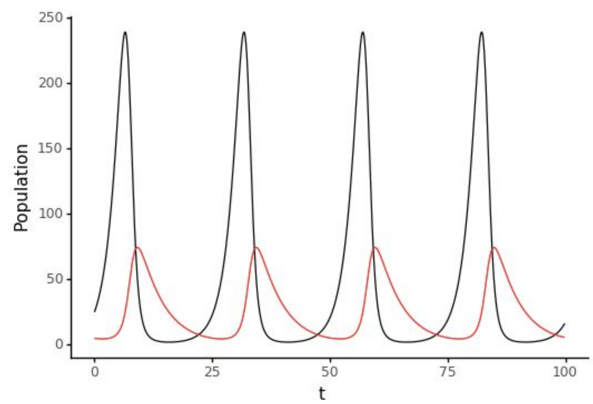
<ggplot: (276896833)>
a Doubled



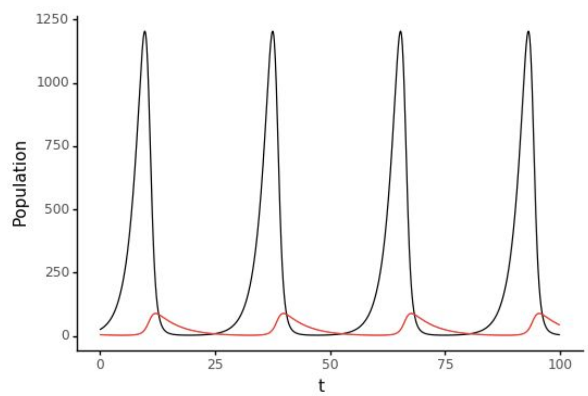
<ggplot: (7532431733)>
a Halved

The above graphs represent doubled and halved predator attack rate a, respectively. Doubling predator attack rate decreases the length of the predator-prey cycle, and produces curves that appear marginally smoother than the original parameters. Halving predator attack rate produces a longer predator-prey cycle, with comparatively sharper curves and a much more significant period of time at which population of prey is at an apparent zero.

<u>Conversion Efficiency of Prey to Predators, e</u>



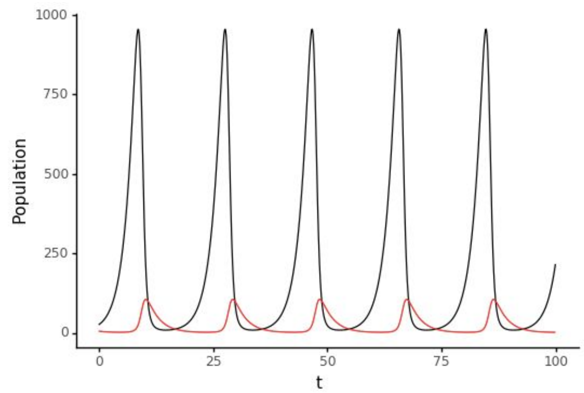
<ggplot: (276896873)>
e Doubled



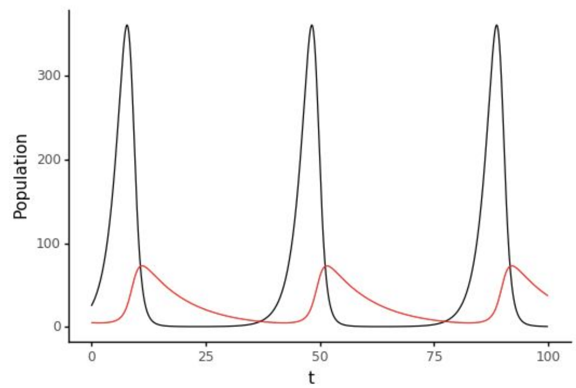
<ggplot: (283372669)>
e Halved

The above images represent doubled and halved conversion efficiency of prey to predators e, respectively. Modifying e by a factor of two in either direction does not appear to affect the maximum value of predator population significantly, but rather affects the ratio of predator-to-prey populations. Doubling e leads to a predator-to-prey ratio of roughly 2:7, while halving it leads to a predator-to-prey ratio of 1:16. Compared to an original ratio of about 1:6, the differences are remarkable. The length of the predator-prey cycle is marginally affected, and doubling e leads to a shorter cycle while halving it leads to a longer cycle.

Predator Death Rate, s



<ggplot: (7532174713)>
s Doubled



<ggplot: (7544602809)>
s Halved

These final graphs represent the effects of doubling and halving predator death rate s, respectively. The most significant difference caused by these modifications is observed in the length of the predator-prey cycle. Doubling s leads to a significantly shorter predator-prey cycle, while halving s leads to a significantly longer predator-prey cycle when compared to the original parameters. This parameter also affects the ratio of predators to prey, as doubling s leads to a larger difference between predator and prey populations, while halving it reduces the difference.

Role of Predators

Predators in the L-V model serve as a limiting factor for prey population, and determine both growth rate and maximum size of the prey population. Predators also determine the length of the predator-prey cycle more significantly than the prey population. A higher population of predators naturally requires a higher rate of prey deaths, leading to a faster predator-prey cycle. The predator-prey cycle relies on an inhibitory relationship between the two populations. As soon as one population rises to a threshold level based on parameters, the other population will change to modify the initial population. For example, if prey population grows too large, predator population will grow large in response, causing the prey population to decrease. This, in turn, will cause the predator population to decrease. In a sense, the two populations are in a constant battle with one another for equilibrium, but neither is ever allowed to achieve a steady equilibrium. What results is a sort of cyclical equilibrium that relies on both predator and prey to maintain itself over time.

Parameters vs. Predator-Prey Cycle Length

The apparent effect of each parameter on predator-prey cycle length is detailed in the below table, along with the evidence that suggests the relationship.

Parameter	Relationship to Pred-Prey Cycle Length	Evidence for Relationship
P	Negative, linear relationship	Doubling p shortens length, halving p increases length
H	Negative, linear relationship	Doubling H shortens length marginally, halving H increases length marginally
b	Negative, linear relationship	Doubling b shortens length, halving b increases length
a	Negative, linear relationship	Doubling a shortens length, halving a increases length
e	Negative, linear relationship	Doubling e marginally shortens length, halving e marginally increases length
s	Negative, linear relationship	Doubling s shortens length, halving s increases length