Population Simulation: A Study on Gene Variance

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The Selfish Gene

PURPOSE

The purpose of this experiment was to create a sample population and track how the population fluctuated, as well as variables within the population. My goal was to simulate evolution of popular traits within a population, and track what combination of these traits allowed for the population to thrive.

HYPOTHESIS

For a sample size of 50 Namus, I believe that the population within the first few days will start to decrease until a certain point.

For this same sample size, I hypothesize that the Namus remaining after 100 days will mostly possess the selfish gene.

My analysis is quite simple; Namus with the selfish gene have an incredibly high chance of reproducing. They always win in encounters with another Namu. However, there are a certain level of selfish Namus that must balance out with non-selfish Namus. A society of only selfish Namus will end up declining, however, a society with balance between selfish and unselfish Namus may allow for the population to grow. Selfish Namus do up the birth rate, however, that is simply because they do not *always* pass on their selfish genes.

SET-UP

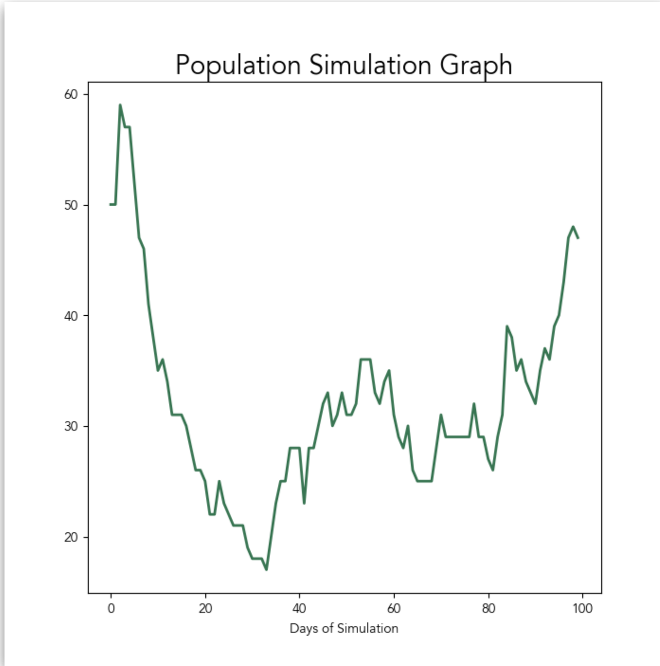
I created a basic organism, which I called Namu. Each Namu starts with full health (100 HP), and based on a random probability, it will simulate every day with the goal of looking for food. If the Namu finds food early during the simulation, their health will be fully replenished. However, if the Namu finds food late in the day, they will gain up to 75 HP, not being at full health.

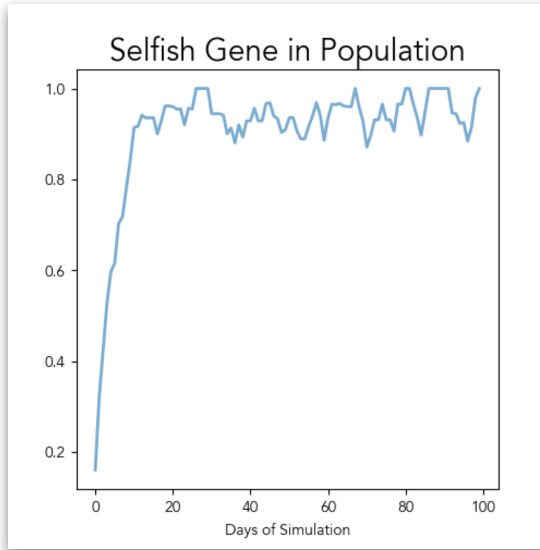
The first gene variation I added was the "Selfish Gene", which gives Namus a better chance to fend for themselves. Let's say two Namus both find a piece of food. If both have the selfish gene, they will both eliminate themselves from the population. If only one has the selfish gene, it will take the food, but not fully replenish its energy. The other Namu is left with no food.

Last but not least, *all* Namus have a chance to reproduce. If a Namu has any specific trait, they have a high chance of passing that trait to their children. Namus have a 20% chance of having twins and a 10% chance for triplets. Within these twin and triplet batches, there is a 50% gene split for and a 67% split favoring genetic inheritance respectively.

With these basic principles, let's start with a sample population of 50 and track it over 100 days. I will run this experiment multiple times and show the results from a society that was on the verge of an increase following this 100 day trial period.

RESULTS & ANALYSIS





At the beginning of the population's instantiation, absolutely nobody possessed the selfish gene, and it was a recessive trait. However, one can notice within the first ten days, as the selfish gene's population percentage was on the rise, so was the population. My analysis in the hypothesis section specifically alluded to how selfish-gene possessing Namus "do up the birth rate… because they do not *always* pass on their selfish genes". However, whenever most of the population had selfish genes, the population rate fluctuated rapidly. It seems as if non-selfish Namus were being bred at a rate slightly above their mortality rate, as with the largest decrease in selfish Namus at around 90-ish days, we see the population skyrocket with non-selfish Namus.

Running the trial again with a 500-day 'positive' simulation resulted in the population finishing at around 7 Namus. However, it had substantial growth during periods where selfish Namus were being replaced by non-selfish Namus during a selfish Namu population domination period (a period when the selfish Namus account for the highest percentage of the population). The society keeps overthrowing this balance, which means that it's time for another gene to enter the pool. But since I'm feeling capricious, why not introduce two more gene variations?

The Intelligent and Sturdy Genes

PURPOSE

The purpose of introducing new gene varieties within the society is to see which genes would be favored, assuming genes cannot overlap (i.e. there is a singular choice of gene). These simulations will occur over a large period of time, and will (for the most part) work the same way as the previous simulation.

HYPOTHESIS

For a sample size of 25 Namus, with a period of 100 days, I expect a balance between the selfish and intelligent Namus, due to them being in constant competition with one another. My expectation is that sturdy and normal Namus will be worth the majority of the population, since sturdy Namus discourage competition amongst other Namu types and simply have a better chance of surviving within every circumstance.

My reasoning behind a result featuring heavy prevalence of the sturdy gene is simple: sturdy Namus have a higher chance of survival compared to their gene-blessed counterparts in *every* non-competitive scenario. And plus, they have a (mostly) constant chance of survival within most categories. Simply put, since sturdy Namus can survive in one day without food, their chance of making it to a day where they do get food is significantly higher.

SET-UP

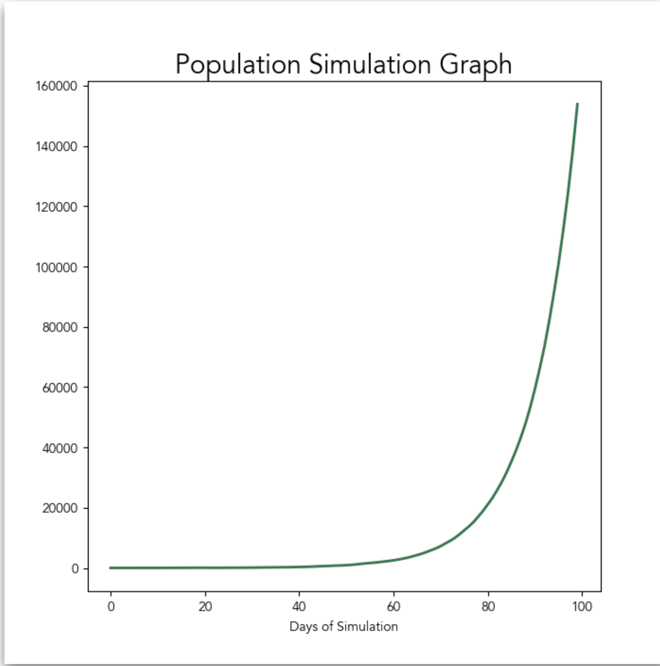
I decided to implement the sturdy gene first. The simple property of the sturdy gene is that it allows for Namus to keep a larger portion of the health that they might lose. For example, if a Namu wasn't able to find food during the entire day, it would typically lose half of its health. This applied to both regular and selfish Namus. However, with a sturdy Namu, it will only lose a quarter of its health. In situations in which sturdy Namus must fight with selfish Namus, sturdy Namus will choose not to fight, taking some damage, but saving their energy and health for the next day in order to find food peacefully.

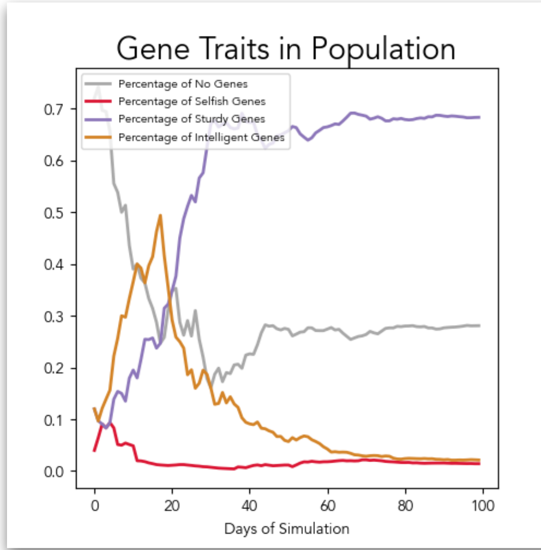
Now my goal was to implement the intelligent gene. I didn't want to give each gene a *significantly* greater power than its genetic counterparts, so with the intelligence gene, I simply gave the Namu the ability to communicate with other Namus. If an intelligent Namu wasn't able to find food the entire day, it would function the same as non-sturdy Namus. However, the catch is: if the intelligent Namu must compete with another Namu for food, it can barter with the Namu to split the food, keeping both Namus alive for another day.

To keep the experiment interesting, however, I added interactions between each Namu type. Intelligent Namus cannot convince selfish Namus, and they could simply take all the food in the case of interacting with a sturdy Namu. This allows for both genes to have a weakness, which may encourage more competition within my simulations.

The Intelligent and Sturdy Genes

RESULTS & ANALYSIS





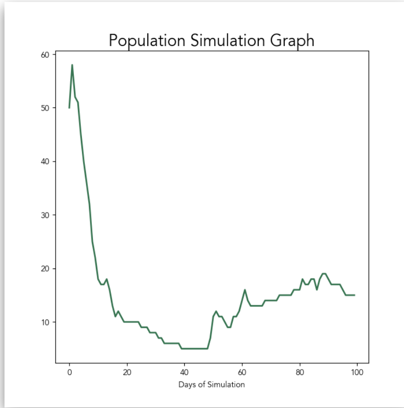
Starting with around 25 Namus, we reach a final population of 171,056 by 100 days. This is eerily different from the previous simulation, as that society was unbalanced; I had more runs resulting in total societal collapse with the previous gene pool. The percentage of selfish and intelligent gene traits are 1.4% and 2.1% respectively, which would account for around 6,000 Namus total. What surprised me was the percentage of "No Gene" Namus. I expected both the selfish and intelligent genes to even out at a higher percentage. However, when considering that Namus' main competition was the selfish gene, which started competing with the intelligent gene, the Namus have nothing to be afraid of; not only that, but sturdy genes are more benevolent and can last longer. In the case that a regular Namu finds the same piece of food as a sturdy Namu, the sturdy Namu will let the regular Namu have the food and survive sans confrontation.

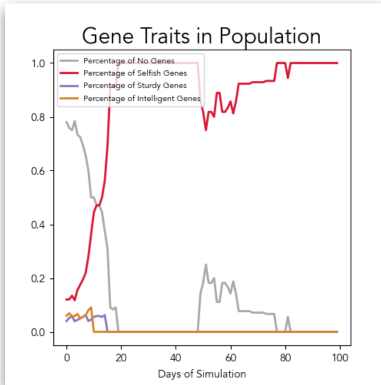
The average health of this population was 76.2, which makes sense considering that the vast majority of sturdy Namus survive with just 75 HP every single day. There wasn't anything that surprised me, however, I had multiple runs where selfish genes kept overpowering intelligent genes. I solved this through making confrontation more difficult and strengthening the intelligent and non-genetic Namus.

Other Graphs

Hypercompetition

Where fighting for food constantly is the norm.





STATISTICS

Population: 15

Geneless: 0%

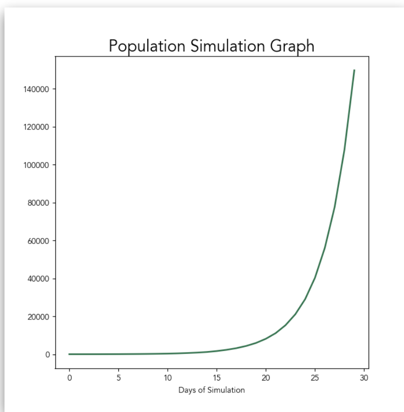
Selfish: 100%

Sturdy: 0%

Intelligent: 0%

Hypocompetition

Let's be friends! Or at least let me reproduce.



STATISTICS

Population: 207,790

Geneless: 62.5%

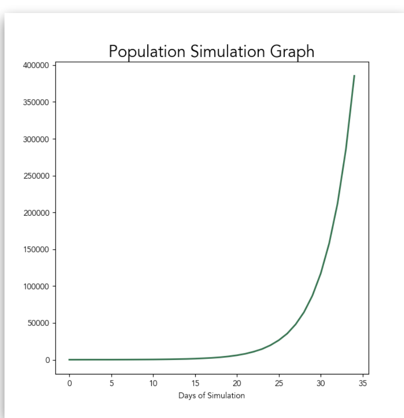
Selfish: 4%

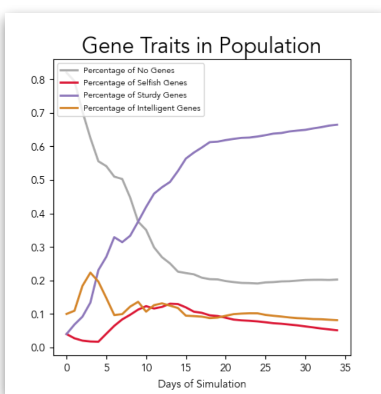
Sturdy: 13.5%

Intelligent: 20%

Hypercompetition & Hyper-reproduction

Fine, let me die. I got a whole family already.





STATISTICS

Population: 519,616

Geneless: 20.4%

Selfish: 4.9%

Sturdy: 66.7%

Intelligent: 8%

Conclusion

WRAP UP

Through testing various populations with various constraints, I have been able to gain a better understanding of each gene's strengths and weaknesses. In scenarios that are hyper-competitive, Namus that end up with *any* amount of food win out. For gene types such as sturdy, which tend to be non-confrontational and would rather starve than duke it out, there was a significant drop off in population. However, intelligent genes, which would have a chance of having *some* food, didn't have enough food to make a significant difference. This let the selfish genes run rampant and take over the majority of the population. In hypo-competitive scenarios, regular Namus didn't have the pressure of fighting for food as much, and since they were a majority of the population to begin with, they remained at the top. Genes such as intelligence flourished; however, only because regular Namus have a higher chance of evolving into their intelligent counterparts. Last but not least, within the hyper -competitive and hyper-reproductive societies, selfish genes had the highest chance of garnering a strong lead early-on, and within most of my simulations, this was true. However, since this was the most realistic society, I saw a wide variety of outcomes. Most of the populations stabilized, however, and within these societies it were the sturdy Namus who controlled most of the population. I believe this to be the case only because of the hyper-reproductive quality; these sturdy Namus (once the population was high) were able to survive at a higher rate and reproduce more. More sturdy Namus could reproduce, although they would also die at a higher rate. Their mortality rate stabilized as a result of "sturdy population dominance" and they ended up winning in the long run.

This was a very fun experiment for me to simulate; I had always been keen on testing out evolution within competitive societies, and I wanted to learn more about how "nice" genes (sturdiness) would compete with "selfish" genes (selfishness).

Upon my next run-through, I plan to include gene mutations and also introduce mixed genes, or Namus that can possess multiple gene traits.

I hope you enjoyed reading my analysis of this population simulation, and I hope you gained more insight into gene survival rates within competitive environments!