Introduction

Natural Selection is the process by which a species is able to adapt to their environment that benefits them and allows for their survival and reproduction. Variation is a critical factor in the process of Evolution and Natural selection, those who are better equipped to their environment have a better chance at survival, and therefore are more likely to replace the gene pool. This can change the entire species generation by generation. The population growth of a specific species of animal, in this case bunnies, is determined by a varying number of factors that can be both quantified and evaluated. Factors such as the prevalence of certain physical traits, or phenotypes, present within the population can be quantified graphically. While the species response to a sudden change in environmental factors can be observed visually. In short, when these attributes coincide, it affects the size of the system (population). This natural selection lab simulation introduces the audience to the involvement of various dominant and recessive traits, known as alleles, that are responsible for a species' survival or demise. The initial lab simulation showcases three separate traits passed down from parent to parent through gene mutations: fur color, ear type, and teeth type. Thus, the purpose of this lab is to determine which combination of gene mutations coupled with environmental factors would lead to one of three instances: unbounded population growth (bunnies have taken over the world), bunnies have all died, and a stable population that borders along its carrying capacity.

Hypothesis: If the bunny population was subjected to a sudden change in climate, then the population would not die out if there were still varying fur mutations present within the populace.

Methods

We developed four separate plans to test the validity of our hypothesis. Our experiment begins by subjecting the bunnies to four differing climate scenarios. In the first two scenarios the bunny population will inhabit a sunny desert biome and a snowy tundra biome. In the later two scenarios the rabbit population will initially inhabit the desert or tundra biome, and several generations down the line, the climate will abruptly change to its polar opposite, from desert to tundra or vice versa. The respective procedures for each plan are as followed:

Tundra-Desert Experiment: First, select the snowflake icon. Set brown fur and floppy ears as recessive traits, while setting teeth as a dominant trait. Then select the 'Add a Mate' icon. Click the fast-forward button until the bunny population reaches the fifth generation. Next, pause the simulation at the start of the fifth generation and click both the sun icon and the 'Wolves' box in the Environmental Factors. Add the 'Tough Food' factor when the population is about to exceed its capacity.

Desert-Tundra Experiment: First, select the sun icon. Set brown fur and floppy ears as dominant traits while setting teeth as recessive traits. Then select the 'Add a Mate' icon. Click the fast-forward button until the bunny population reaches the fifth generation. Next, check the 'Wolves' box in the Environmental Factors. Once the population reaches the eighth generation immediately click the snowflake icon to switch the environment to a tundra. Add the 'Tough Food' factor when the population is about to exceed its capacity. Finally, check the 'Limited Food' box to create a stable population and prevent it from growing unbounded.

Control Groups: Control groups are within the *Tundra-Desert* and *Desert-Tundra* from Generations 0-5.

Results and Data

Tundra-Desert

Generation #	Start-End Population # of White Fur Rabbits *Start # -* $End\ \#_{after\ Wolves}$ - $End\ \#_{after\ Tough\ Foo}$	Population # of Brown Fur Rabbits	Short Teeth Population #	Long Teeth Population #	Straight Ear Population #	Floppy Ear Population #
0	**2**	**0**	**2**	**0**	**2**	**0**
1	**6**	**0**	**5**	**1**	**6**	**0**
2	**18**	**0**	**15**	**3**	**18**	**0**
3	**54**	**2**	**48**	**8**	**54**	**2**
4	**166**	**2**	**142**	**26**	**164**	**4**
5*	**493-/**	**5-/**	**419-/**	**79-/**	**490-/**	**8-/**
5	**493-52**	**5-5**	**419-45**	**79-12**	**490-55**	**8-2**
6	**157-28**	**6-4**	**129-22**	**34-10**	**160-31**	**3-1**
7	**87-9**	**9-5**	**68-9**	**28-5**	**95-14**	**1-0**
8	**27-2**	**10-6**	**24-3**	**13-5**	**37-8**	**0-0**
9	**10-1**	**14-9**	**10-5**	**14-5**	**24-10**	**0-0**
10	**3-0**	**27-17**	**16-11**	**14-6**	**30-17**	**0-0**
11	**0-0**	**49-31**	**32-20**	**17-11**	**49-31**	**0-0**
12	**0-0**	**91-58**	**59-38**	**32-20**	**91-58**	**0-0**
13	**0-0**	**174-110**	**114-72**	**60-38**	**174-110**	**0-0**
14**	**0-0-0**	**324-210-64**	**214-146-26**	**110-64-38**	**324-210-64**	**0-0-0**
15	**0-0-0**	**192-121-44**	**81-53-6**	**111-68-38**	**192-121-44**	**0-0-0**
16	**0-0-0**	**132-86-46**	**25-12-2**	**107-74-44**	**132-86-46**	**0-0-0**
17	**0-0-0**	**133-82-43**	**16-11-2**	**117-71-41**	**133-82-43**	**0-0-0**

18	**0-0-0**	**127-76-43**	**12-5-1**	**115-71-42**	**127-76-43**	**0-0-0**
19	**0-0-0**	**127-81-45**	**9-4-1**	**118-77-44**	**127-81-45**	**0-0-0**
20* **	**0-0-0**	**132-85-49**	**5-1-0**	**127-84-49**	**132-85-49**	**0-0-0**
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49* **	**0-0-0**	**768-/-/**	**1-/-/**	**767-/-/**	**768-/-/**	**0-0-0**

*The control group for Tundra-Desert ends at the start of Generation 5. Proceeding Generations involve the Environmental Factor 'Wolves' and the shift in climate from a tundra to a desert.
** The Environmental Factor 'Tough Food' is involved starting in Generation 14.
***After Generation 20 total population steadily increases unbounded until Generation 49.

Desert-Tundra

Generation #	**Population # of White Fur Rabbits** *Start #* - $End\ \#_{after\ Wolves}$ - $End\ \#_{after\ Tough\ Foo}$	**Population # of Brown Fur Rabbits**	**Short Teeth Population #**	**Long Teeth Population #**	**Straight Ear Population #**	**Floppy Ear Population #**
0	**2**	**0**	**2**	**0**	**2**	**0**
1	**5**	**1**	**6**	**0**	**5**	**1**
2	**15**	**3**	**18**	**0**	**15**	**3**
3	**46**	**9**	**53**	**2**	**47**	**8**
4	**136**	**27**	**160**	**3**	**137**	**26**
5*	**402-/**	**79-/**	**476-/**	**5-/**	**406-/**	**75-/**
5	**402-39**	**79-48**	**476-86**	**5-1**	**406-77**	**75-10**
6	**127-14**	**131-80**	**256-93**	**2-1**	**228-83**	**30-11**
7	**61-7**	**215-132**	**275-139**	**1-0**	**245-126**	**31-13**
8 **	**50-31**	**365-42**	**415-73**	**0-0**	**374-64**	**41-9**

9	**76-49**	**141-25**	**217-74**	**0-0**	**190-65**	**27-9**
10	**131-79**	**86-8**	**217-87**	**0-0**	**190-76**	**27-11**
11	**230-148**	**28-5**	**258-153**	**0-0**	**229-136**	**29-17**
12* **	**439-264-40**	**12-1-1**	**451-265-41**	**0-0-0**	**403-229-38**	**48-36-3**
13	**118-73-14**	**3-0-0**	**121-73-14**	**0-0-0**	**110-63-10**	**11-10-4**
14	**42-27-3**	**0-0-0**	**42-27-3**	**0-0-0**	**30-21-2**	**12-6-1**
15	**7-5-1**	**0-0-0**	**7-5-1**	**0-0-0**	**4-4-0**	**3-1-1**
16	**1-0-0**	**0-0-0**	**1-0-0**	**0-0-0**	**0-0-0**	**1-0-0**

*The control group for Desert-Tundra ends at the start of Generation 5. Proceeding Generations involve the Environmental Factor 'Wolves'.
**A shift in climate from a desert to a tundra is present at the beginning of Generation 8
*** Environmental Factor 'Tough Food' is involved starting in Generation 12

The Tundra-Desert experiment demonstrated how white furred rabbits were able to rapidly grow their population initially with the influence of their dominant gene and no predators. However, once the climate was switched from a tundra to a desert white furred populations began to decline exponentially, so much so that by the tenth generation no white furred rabbits were present in the populace despite white fur being the dominant gene. Similarly, the Desert-Tundra experiment reinforced the idea on how certain traits that are unsuitable for one environment can be optimal for another. During the beginning of the Desert-Tundra experiment the majority population were white furred rabbits. When wolves were introduced during the fifth generation white furred populations began to decrease and their counterparts began to increase. At one point in time, the end of the seventh generation, white furred rabbit populations declined to a mere ten rabbits. However, when the climate switched from a desert to a tundra, white furred populations began to recover and climb again. On the other hand, brown rabbits started with a population of 356 at the start of the eighth generation but by the end it plummeted to a

population of 42. This was the result of introducing another variable, the climate, one that favored a specific group of animals with special adaptive characteristics. As a result, climate sensitivity is a vital concern for the population density of rabbits, as a slight change in temperature could be catastrophic (Alves et. al, 2008).

Discussion

The results from the two climate shift scenarios supported our hypothesis that if there is varying fur mutation within the populace then the population will not die out if exposed to an abrupt change in environment. Our control groups served to exemplify the different population density of rabbit fur prior to any variables being implemented. The conclusion that can be drawn from the results of the Desert-Tundra experiment is that the remaining white bunnies that had not perished by the wolves near the end of the seventh generation will adapt much quicker when the climate changes from a desert to a tundra. This is due to their recessive white fur enabling them to survive in this new environment better than the one prior. This is evident according to (Lenormand, 2002), species in this scenario would likely migrate to another environment where their alleles are better suited for their survival. However, this is not the case in our simulation. Brown furred bunnies can't survive long enough to produce offspring with recessive traits that can survive in the tundra. When adding a third variable,'Tough Food', to the Desert-Tundra experiment, right when the white fur population hit its peak, the results indicated that the entire bunny population went extinct after four generations. We could infer that the explanation behind this quick mass extinction was the result of recessive long teeth being bred out of the population due to it being negligible for the population's survival. For this particular simulation, we set long teeth traits as recessive and maintained the same default food source. Subsequently, there was simply no need for this recessive trait after the population had already adapted to living off of

their starting food source for multiple generations. If ‘Tough Food’ had not been introduced so far down the generational line and so suddenly, but instead at the beginning where bunnies with recessive long teeth mutations were still in existence, albeit a miniscule part of population, then the population could be more readily adjustable to this new variable. This was made clear in the Tundra-Desert experiment which demonstrated the result of setting the teeth gene as a dominant gene. Consequently, a significantly larger portion of the population had large teeth than the previous experiment due to it being a dominant strain. By Generation 49 the brown fur population with large teeth was even able to overcome wolf predation through reproduction at greater rate than the wolves can hunt. In summary, genetic traits, heredity, and environmental variables all intertwine to play a role in determining the outcome of a species’ population. Lastly the environmental factor ‘Limit Food’ prevents unbounded population growth such as the instance with the Tundra-Desert experiment.

Conclusion

In conclusion, we have seen that natural selection plays a role in how the bunnies adapt to the changes of the environment that they were put through. Also by changing how they look from the fur, to the ear, and the teeth this also affects the way they survive in the environment that they have been exposed to. These different aspects show that since these bunnies had the same exact features but were put into two different environments that went from desert to tundra and tundra to desert it has been proven that eventually the bunnies would not die out at a certain generation.

Reference

Lenormand, T. “Gene Flow and the Limits to Natural Selection.” *Trends in Ecology & Evolution*, vol. 17, no. 4, 2002, pp. 183–189., https://doi.org/10.1016/s0169-5347(02)02497-7.

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