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Integrating the Radiation Resistance Allele into the Mountain Men Genome

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Abstract

The CW's *"The 100"* introduces 3 separate populations of humans: the Sky People, the Grounders and the Mountain Men. The Sky People possess an allele that allows them to survive the increased radiation levels on the surface of Earth. Dante Wallace, leader of the Mountain plans to integrate 48 Sky people with the 382 members of the Mountain Men population. This is modelled using the Hardy-Weinberg principle showing ~20 % of subsequent generations to be radiation resistant and then the Wright-Fisher model to determine the probability of the allele becoming fixed into the population (~11%) and the number of generations required to do so (~262).

Introduction

The CW's *"The 100"* is set in a dystopian future in which the Earth is uninhabitable due to a nuclear event. This sets up a dynamic in which a population, thought to be the only survivors by surviving on 12 international space stations and brought together to form the Ark, send 100 young adolescents of reproductive age to the surface. The purpose of this is to see whether 3 generations later the surface has become inhabitable as resources on the ark are depleting. It is found that they are able to survive on the surface.

The Grounders and the Mountain Men

Unknown to them, there are 2 populations of *Homo sapien* that have survived on the surface: the Grounders and the Mountain Men. The survival of these three populations has occurred in different ways and as such they have different traits.

The survival of the Grounders has occurred via natural selection with this population having acquired mutations that have provided a degree of radioactive protection. The Mountain Men however, have survived in a large nuclear bunker within Mount Weather and are unable to survive outside.

The 100, or the Sky People, have also developed resistance to the radiation. However, it is explained that the evolutionary processes that have lead to an

increase in tolerance to radiation are far greater than that of the Grounders.

By the end of the first season of *"The 100"*, it is discovered that 48 of the initial 100 have been rescued/captured by the Mountain Men [1].

Dante's Plan

Dante Wallace, the president of the Mountain Men, has an initial idea to fully integrate the 48 into their 382 strong population, in order that in subsequent generations the Mountain Men may once again be able to walk on the surface by introducing the resistance gene within the population [1]. This plan can be evaluated using Population genetics.

Population Genetics - Assumptions

It is assumed that one gene is responsible for conferring the resistance to radiation, existing as two alleles, *A* (resistant) and *B* (non-resistant). It is also assumed the 48 Sky People are homozygous *A*, whilst the 382 Mountain Men are homozygous *B*, leading to a total of 860 alleles present in the combined population, 96 *A* and 764 *B*. For the purpose of the models presented allele *A* is taken to be dominant, as if natural selection were to be a factor it would provide the greatest fitness. The consequence of this is that members of the population that are homozygous *A* or heterozygous would have acquired resistance to radiation.

Hardy-Weinberg Principle

The Hardy-Weinberg principle states the allele and genotypic frequencies within a population remain constant throughout subsequent generations. This occurs only when evolutionary processes are absent [2].

The frequencies at which this occurs is known as the Hardy-Weinberg equilibrium (HWE) and are given using the equation:

$$p^2 + 2pq + q^2 = 1$$

where p and q are the allele frequencies of the dominant and recessive alleles respectively.

Applying this to the combined population outlined, genotypic frequencies would be given by:

$$\left(\frac{96}{860}\right)^2 + \left(2 \times \frac{96}{860} \times \frac{764}{860}\right) + \left(\frac{764}{860}\right)^2$$

with the terms representing homozygous A , heterozygous and homozygous B respectively.

The result of this is that with the allele frequencies present within the current population, subsequent generations would reach HWE with a population in which 1.25 % would be homozygous A , 19.83% heterozygous and 78.92% homozygous B . This means that for a population of this size ~90 individuals would be able to walk on the surface.

Genetic Drift

It is evident that evolutionary processes are required in order to increase the prevalence of radiation resistance within subsequent generations.

One such process is genetic drift; the change is allele frequency in a population due to random sampling. In finite populations, such as the one presented, genetic drift can cause an allele to become fixed within the population as the random sampling can cause an allele to disappear from the population. As such genetic drift appears to be a process that removes variation from the population [3].

The Wright-Fisher model can be used to describe the change in allele frequency over time based upon their initial frequencies within the population.

The assumptions made in the Wright-Fisher model are similar to those in the Hardy-Weinberg principle [2].

The Wright-Fisher model can be used to determine the probability of the allele A becoming fixed within the population, and extended to determine the number of generations required for this to occur.

The probability of an allele becoming fixed within a population is given by the allele frequency [2]:

$$n(A) \times \frac{1}{2N}$$

where n is the number of A alleles and N is the size of the population. For the combined population of Sky People and Mountain Men, the probability of allele A , the resistance allele, becoming fixed in the population is found to be 0.11 or ~11%.

The time taken to reach allele fixation is given by the equation [4]:

$$\tau(p) = -2 \times 2N \times (p \log p + q \log q)$$

where $\tau(p)$ represents the number of generations required for fixation of allele A . For the combined population of Sky People and Mountain Men, the number of generations required to fix allele A into the population is found to ~262.

Conclusion

Modelling subsequent generations of the combined population, as proposed by Dante Wallace, using the Hardy-Weinberg principle in the absence of evolutionary processes showed that HWE would be reached with approximately 20% of the population able to inhabit the surface. As Dante's plan involved fixing the resistance allele into the population, the probability of this and the number of generations required were calculated to be ~11% and ~262 generations respectively using the Wright-Fisher Model. The consequence of this would be that, assuming each generation is 20 years, the Mountain Men would have to wait ~5228 years before the entire population was able to inhabit the surface.

References

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