Natural Selection

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1 Introduction

Natural selection is the differential survival and reproduction of individuals due to differences in phenotype. It is a key mechanism of evolution, the change in the heritable traits characteristic of a population over generations. Charles Darwin popularised the term "natural selection", contrasting it with artificial selection, which is intentional, whereas natural selection is not. The process of natural selection is very complex and slow with lots of parameters to consider and for any random instance of the interation set up of the organisms among themselves and with the environment, we find completely different results. Hence, we need to simulate a sample environment multiple times in order to find an expected averaged out result.

1.1 Proposed simplified model

Let us consider a much simplified model of natural selection wherein only one of the traits in the phenotype set is different, in this case, the speed. Let us assume a linear dimensional region of a fixed size (in our case 500) where the species would be present randomly initially the fast moving variation are much less than the slow moving ones. Also, there are a fixed number of food particles (in our case 200) distributed randomly in this region. A fast particle can move a step in one day whereas the slow moving ones take three days for the same. If a creature goes on for a specific amount of time, (in our case 20 days) without encountering any food particle, it dies. If a particle finds two food particles, it uses that energy to create one offspring of its own at the same place. Also, after every 10 days, 40 food particles get redistributed in our locality. Now, as the fast moving particles can find food faster, their chances of survival and proliferation are better than those of their slow counterparts. Hence, the distribution of their population is expected to change. But since any random arrangement can give unfair advantage to a particular variation, we can't trust a particular arrangement. This is where Monte Carlo estimation comes to our rescue. If we take many such simulations, the randomness of the system will favour all types of arrangements equally and hence the bias caused by any particular arrangement is diminished, giving us the expected distribution of the population.

2 Result

Lets us look at the plots obtained for several cases, let a denote the initial number of fast-moving particles and b denote the initial number of slow-moving particles

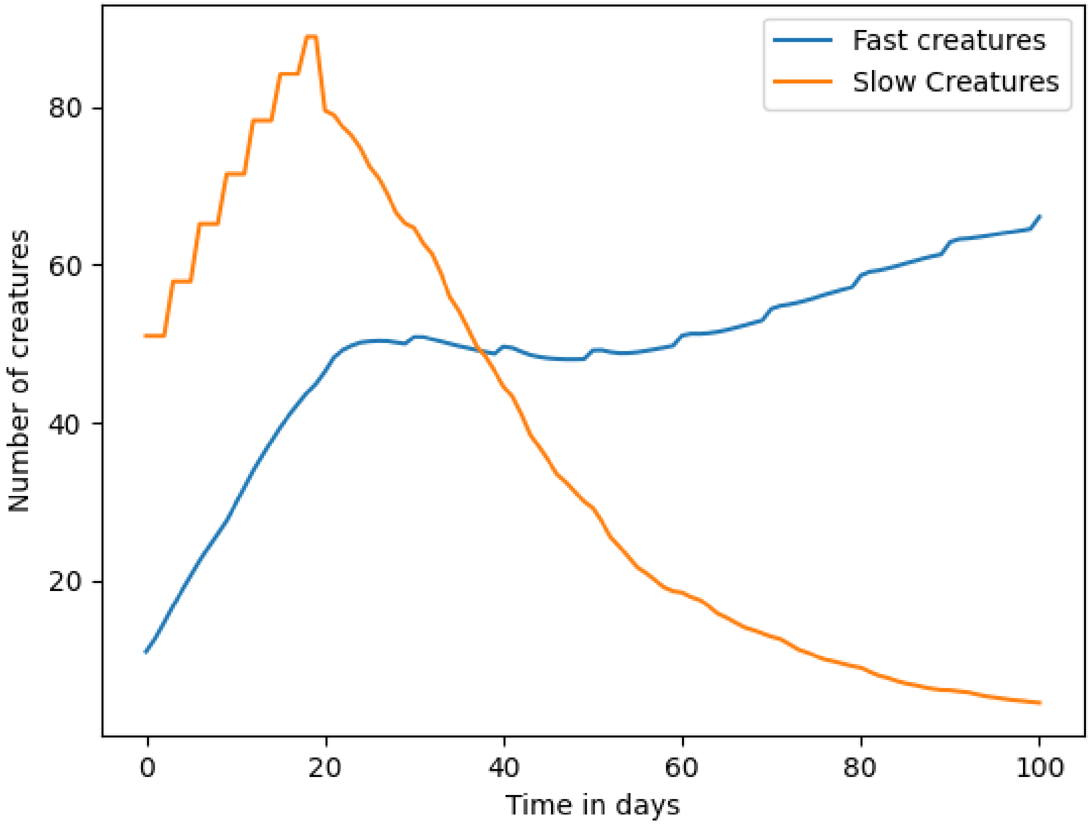

Figure 1: Population vs time when $a = 10$, and $b = 50$
The time when their populations become equal is round 39 days

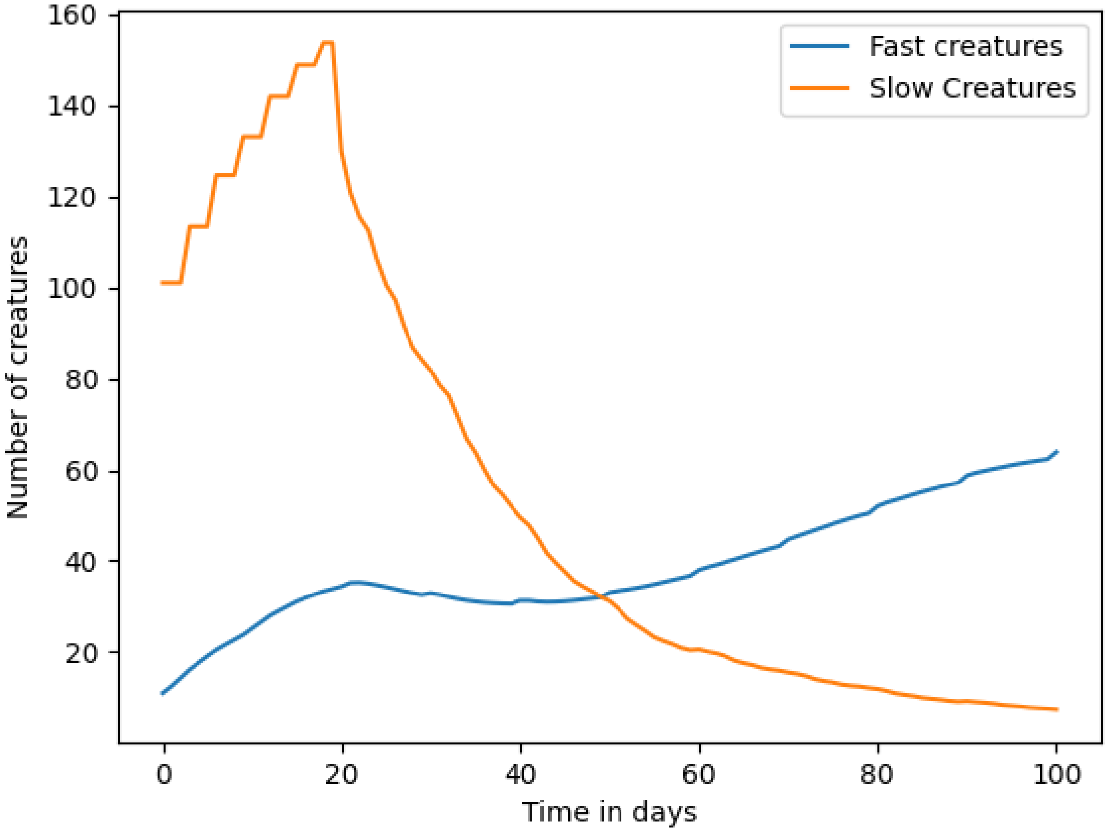

Figure 2: Population vs time when $a = 10$, and $b = 100$
The time when their populations become equal is round 49 days

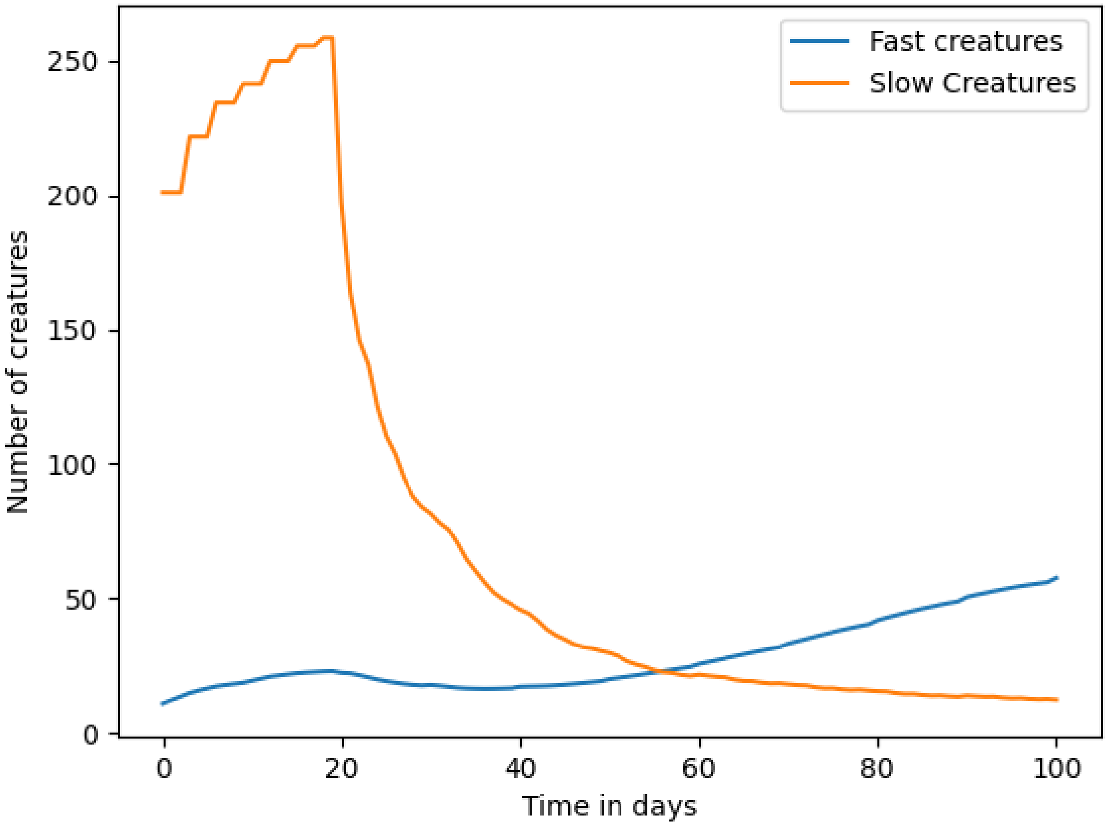

Figure 3: Population vs time when $a = 10$, and $b = 200$
The time when their populations become equal is round 57 days

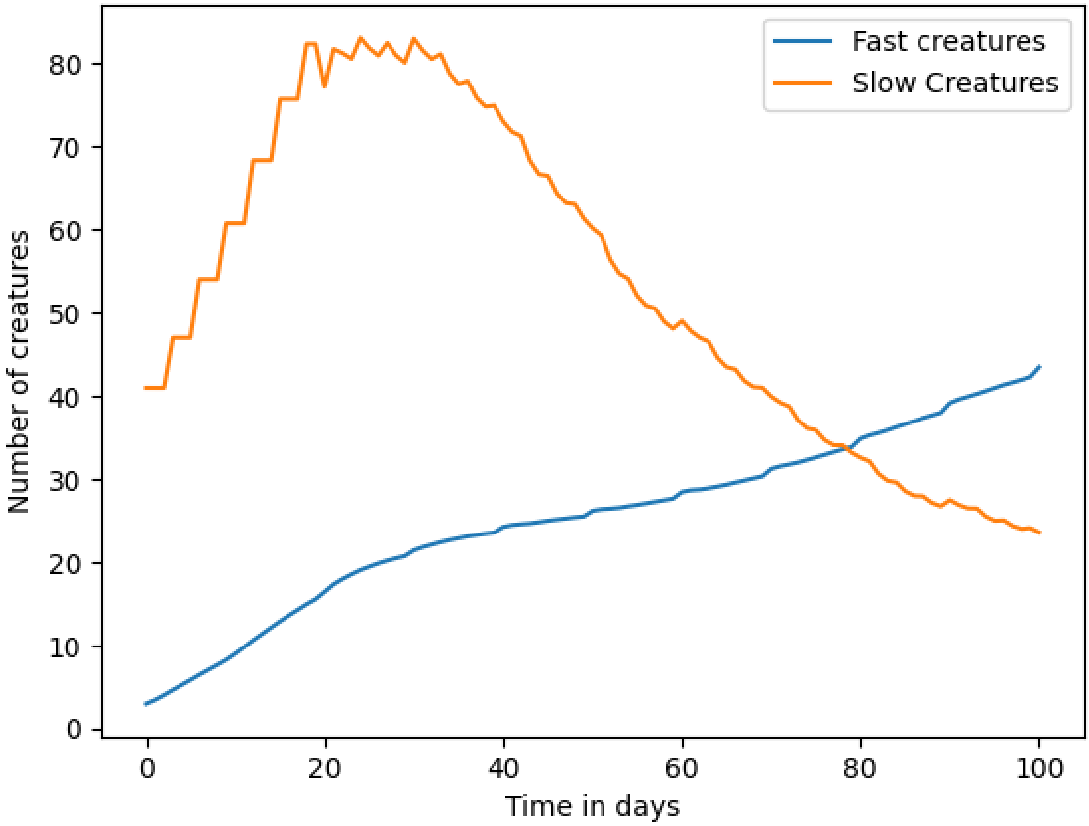

Figure 4: Population vs time when $a = 2$, and $b = 40$
The time when their populations become equal is round 78 days

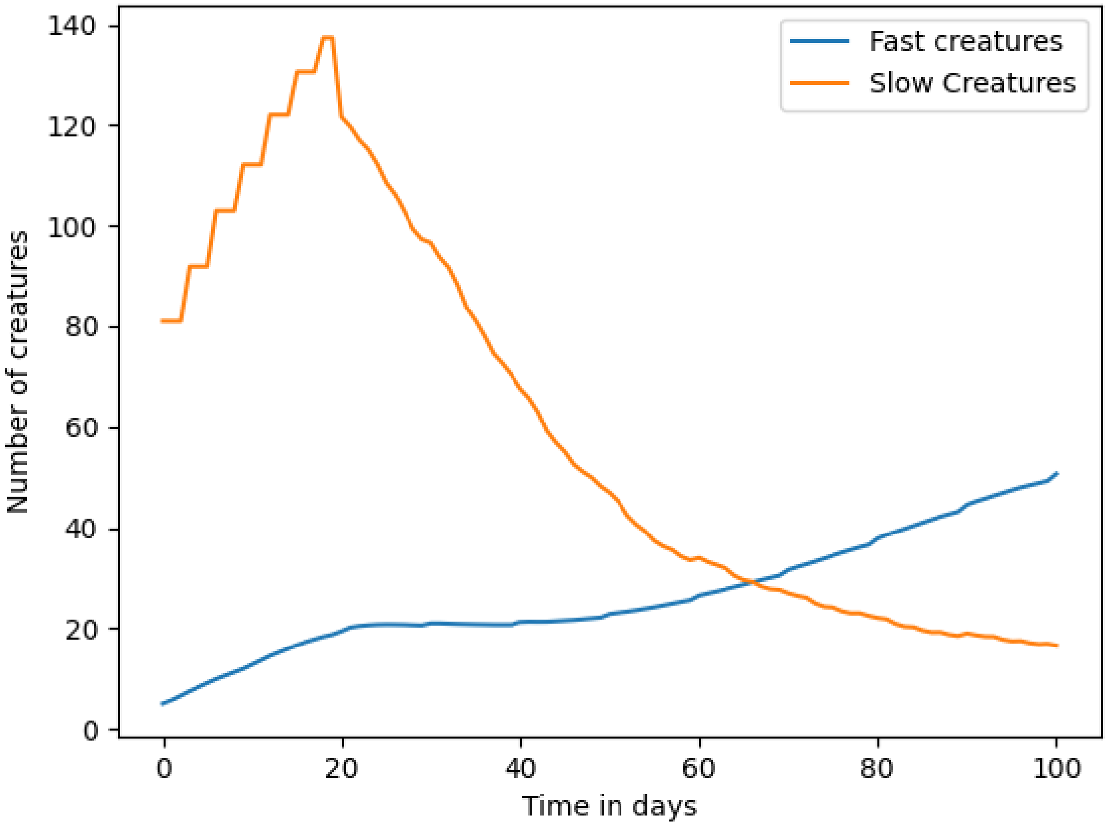

Figure 5: Population vs time when $a = 4$, and $b = 80$
The time when their populations become equal is round 65 days

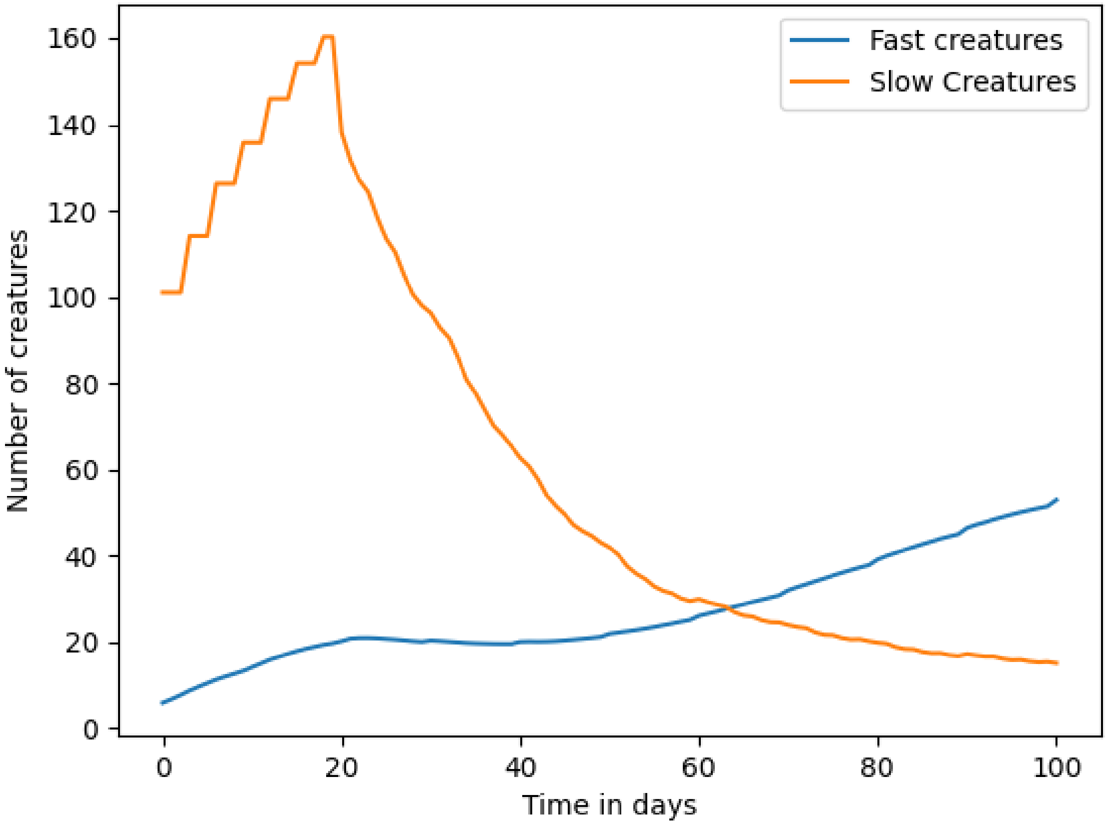

Figure 6: Population vs time when $a = 5$, and $b = 100$
The time when their populations become equal is round 64 days

3 Inference

- We can infer that for all the mentioned cases, though the initial rise in population is high for the slow moving creatures, the fast moving creatures ultimately take over the population as their survival is preferred by nature due to an evolved trait in the phenotype set.
- Though this model is a huge simplification of the actual selection process in nature, we can still expect some of the empirical observations to hold true in real life applications. One loose observation we get is that for a fixed number of fast moving organisms, the increase in the time taken to overtake the slow-moving creatures in terms of population is approximately linear for a certain range of non-extrema exponentially increasing values of the number of slow moving creatures. This can be seen for the example of $a = 10$, where

  - When $b = 50$, the time taken is 39 days
  - When b is doubled to 50, the time taken increases by 10 to 48.
  - When b is quadrupled to 200, the time taken increases by 18 to 57.

  This shows that there might be a logarithmic relation between the two values.

  $$Timetaken = clog(\frac{b}{a}) \tag{1}$$

  where c can approximately be treated as a constant.
- Also, we can predict that for a fixed ratio $\frac{a}{b}$, the overtake is faster for greater values of a, which makes sense as the overtake happens due to the fast moving creatures hogging up all the food, so the more the merrier.

  The results above are quite empirical and might not agree outside some range. But the general trend alwayss remains the same. All we know is that

  > Nature favours "survival of the fittest"