The Effects of Roosters' Behavior

New Mexico Supercomputing Challenge

Final Report

April 1, 2009

Team #17

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Executive Summary

Our project started basically a simulation of how different actions might affect a rooster. The rooster's actions might affect the hens and chicks. If the rooster's behavior affects all the chickens, there might not be any eggs, or something else. It is important for all hens to be healthy so they can produce good eggs and healthy chicks.

Our team began the study to see if and how the rooster's behavior is affected when something happens, such as if a coyote eats one of the hens. We could not find any references on how a chicken acts when a certain event happens. From personal experience of one of us, Hazel, with chickens on a farm, we know that the chickens will try to get away from the predators. We don't know yet if the chickens can learn from experience how to fight the predators, but we think that they may be able to protect themselves from the predators. Then again, this is only a pure guess, since we had no reference to work on.

We used Starlogo TNG to program the simulation to test our theory. We added age to the agents so that the older the chickens would have more experience and are the better at running away from the coyotes. We used a model with several adjustable variables, in order to get different results. We found that, with proper parameters, we can make a chicken survive an encounter with a predator. We also found that to accurately model a real life event, we would need a correct model, proper parameters, and a very fast computer. Our simulation using PC give us results but they do not represent the real life events of the animals in a farm.

Problem statement

We want to study the roosters' behaviors when affected by current events such as a coyote ate most of the hens; when it is too cold that winter and only the roosters survived? Or a disease killed most of the chickens? We would like to know if the roosters could learn how to defense themselves when they see a coyote. If the roosters run away any time they see the coyote what path would they take or they would scatter in all directions? Also, when roosters, hens, and chicks are present at the time the coyote appear what the roosters would do?

We searched the library and the Internet for the references on the roosters' behaviors, but did not find any. However, Hazel, one of our team members, does have some experience with chickens on a farm, so we created our model on that experience.

Method

We worked with chickens and the chickens' predators. We did not, however, work with the chickens' food. We figured that since we were working on domesticated chickens, feeding would not be necessary because the farmers would feed the chickens daily.

We started with some roosters and hens. Each hen would lay about 250 eggs/year. The eggs would hatch after 21 days in incubation. To reduce the chance of a runaway computing process, we set the upper limit on the total eggs, chicks, and chickens the farmer can have at any time.

We introduced two types of predators, coyotes and crows. The coyotes would eat the hens and roosters while the crows would eat the chicks. We also added a couple of dogs as the protectors of the animals on the farm. The dogs will fight and chase away the predators.

We first set up all the agents and tested a few times to see how many of each agent we should put in our model. Then we added movement to the agents and we made it possible for the agents to repopulate. We also added age to the agents, so that they would die if they got too old. We had the line plots to show how many eggs, chicks, and chickens were alive.

To program the software to do simulation properly, we needed to get answers to some basic questions such as:

1. How often can a coyote catch a chicken? Our estimate is one chicken every 2 days.
2. How often can a crow catch a chick? We estimate 1 chick every 2 days.
3. How does a coyote or a crow behave when it gets near a chicken/chick or a dog?
4. Can a rooster learn to fight a coyote? We think that the roosters will try to fight off the crows to protect the hens and chicks. Some will later learn to fight off coyotes too if they survive.
5. What model(s) should be used to simulate the learning experiences of the chicken? We use the equation

   Probability of a chicken be caught by a coyote when they collide $Y = X^{-R}$ where

   $R = (\text{Chicken age})/(\text{Coyote age})$ and X is a variable ≥ 1.

Variables

Chickens

We start with two roosters and ten hens. Each hen has a 68% probability to lay one egg a day (for a total of 250 eggs/year). Some of the eggs will be sold, because we don't want too many chicks. After 21 days most of the eggs will have hatched. Not all of the eggs are fertilized and so a small fraction, 20% in this model, will not hatch. The total egg and chick upper limits are set to be 100 eggs and 100 chicks.

The chicks will grow up to become hens or roosters in 120 days. Some hens and most of the roosters will be eaten or sold. The chickens' population is limited to a certain numbers – 50 hens and 10 roosters. We thought that the population of roosters should be less than the population of hens, because the farmer will keep most of the hens to lay eggs, but he will sell most of the roosters, since they don't do much help, and they don't get along very well together.

The roosters and hens have a maximum of seven years to live, then they will be too old and die, or the farmer will sell or eat them.

The chickens always stay inside the coop. Farmers usually do not want chickens on the run. Also, they might be safer in the coop, and that is what farmers are concerned about.

Coyote: Prey/Predator

In our model the Coyotes will try to eat the chickens, and when a coyote gets near a chicken, it will chase the chicken. The chickens will run away from coyote if they see it. The coyotes will usually run after the hens rather than the roosters, because they are better fed. After the coyotes eat a chicken, it will go back to its den outside of the coop to rest for two days. When the coyote is hungry and is outside the coop, it will try to get in. It has some probability to get into and out of the coop. We programmed this probability as a variable and adjusted it to obtain different outcomes.

When a coyote see a dog, its first priority is to run away from the dog. It only chases the chickens if it does not see any dog nearby.

Coyotes can live a maximum ten years. When a coyote dies, a new one is born, so that we don't have to deal with a variable: how many coyotes there are. If there are always four coyotes, our project will be simpler.

Crows: Prey/Predator

There are 10 crows in our project. The crows can only catch chicks because roosters and hens are big enough to fight back. Crows are usually able to eat the chicks, since the chicks are still young and easy to be caught. When a crow gets near a chick, it will chase the chick. In real life, the crows will sometimes work together to catch a chick, but we did it so that each crow will just try to catch a chick by itself. The crows can move in three Dimensions (3D). The dogs will also chase the crows. When a crow is near a dog, it will fly up, so that the dog will not be able to catch it. We do not have an age for the crows, and the crows cannot die. Doing this makes the project easier by reducing the number of variables.

Dogs

We have two dogs in our project. The dogs are the chickens' protectors. They will try to chase away the coyotes and crows. When a dog catches up with a coyote, it will fight and will be able to kill the coyote sometimes. We use a fixed probability of 10% chance of killing the coyote in our model. This 'fixed' probability is easy to change in Starlogo TNG but we did not try different value.

The dogs only stay inside the coop. They don't have an age, and they can't die.

What We Have Accomplished

We wrote our code using Starlogo TNG and set up to make all the agents react to each other. We added age to all agents (except the dogs and crows) so that the model on the life of the chickens, from an egg to adult, would be more realistic: the chickens would grow up in a timely manner and the older the chickens would have more experience and are better at surviving an encounter with a coyote. It also included that the agents could learn from experience: the chickens would learn how to defend themselves and the coyotes would learn to catch the chickens better.

A day was divided into 100 time units. That is, each cycle of the code would last 0.01 days. This is perhaps too coarse for a realistic simulation since each step would represent about 15 minutes in real life, which is too long. We, however, cannot make the time unit much smaller since then it would take too long to finish a run on our PCs.

The program starts with 10 eggs, 10 chicks, 10 hens, 2 roosters, and 2 dogs distributed randomly inside the coop. The 4 coyotes are somewhat randomly distributed outside the coop and near their dens at the left bottom of the Starlogo platform. The 10 crows are distributed randomly in all 3 dimensions. The ages of these first animals are randomly distributed within the time intervals as follow: eggs – 21 days, chicks – 120 days, chickens and coyotes – 1 year. Figure 1 shows the randomly distributed animals at the beginning.

Figure 1. Distribution of the animals at the start

For the first run, we set the probability for the coyote to get into or out of the coop by crawling underneath the fence (or jumping over the wall) at 40% and set variable X (of the probability of a chicken be caught by a coyote $Y=X^{-R}$) equal to 1. We ran it until all the eggs, chicks, and chickens are gone or when they all are at their upper limits and would not likely go down. We then repeat the run for X = 2, 4, 6, 8, and 10. Figure 2 shows the graphical results of the surviving eggs, chicks, and chickens.

Figure 2. Graphs of the surviving chickens, eggs, and chicks, as a function of the value X. The probability for a coyote to get into or out of the coop is 40%. The roosters are represented by the turquoise lines and the hens are represented by the brown lines in the leftmost graphs. Each unit of the X-axes represents about 5 time units (0.05 days).

In general, the eggs, chicks, and chickens survive longer as X increases. The graphs at X=6 show some oddities. First of all, most of the eggs, chicks, and chickens survived longer than those when X was at larger value. Secondly, they all (except one rooster) appeared to die off at about the same time, 10,000 X axis units (~500 days). Third, there remained one rooster that would not die. We ran the program for 45 minutes after we saw that the rooster was the only one remaining and finally we had to stop the program. Before stopping, we checked the ages of this rooster and the coyotes and found that the rooster has survived for about 1 year and most of the coyotes' ages were much less. This would make this rooster much more experienced than the coyotes and it would have better chance of surviving. Figure 3 shows the picture of the run near the end.

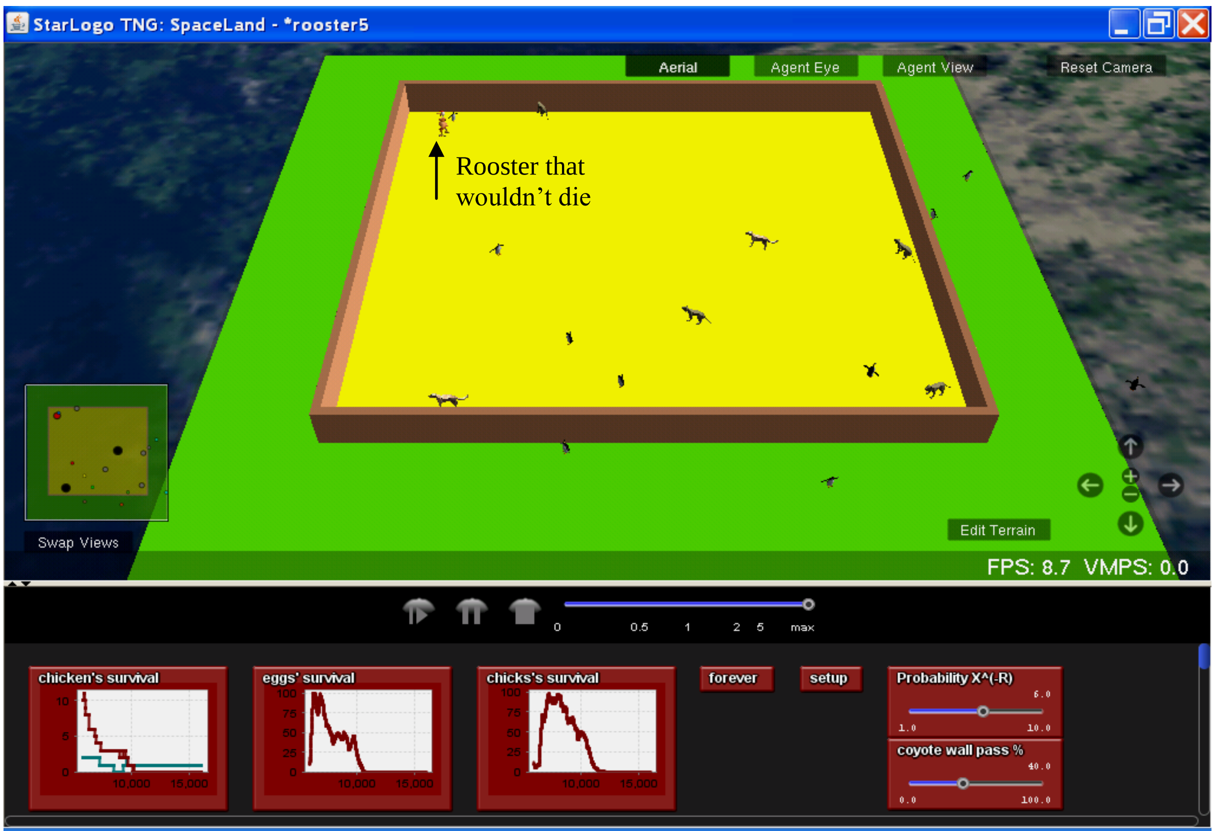

Figure 3. The rooster that wouldn't die

We next set the probability of the coyotes getting into and out of the coop at 10%. We then rerun the program with the X variable equals to 1, 2, 4, 6, 8, and 10 as before. Figure 4 shows the results.

Figure 4. Graphs of the surviving chickens, eggs, and chicks, as a function of the value X. The probability for a coyote to get into or out of the coop is 10%. The roosters are represented by the turquoise lines and the hens are represented by the brown lines in the leftmost graphs. Each unit of the X-axes represents about 5 time units (0.05 days).

Except for a couple of oddities, the general behaviors of the surviving eggs, chicks, and chickens are similar to those in figure 2. We are a bit surprised. Before these runs, we thought that the small probability of getting out of the coop would make the coyotes easier to be caught and killed by the dogs. It turned out that there was another effect that would cancel out the just mentioned effect. Since the coyotes could not get out of the coop easily, they would likely to remain inside the coop for the 2-day period after catching a chicken. Then they would just go back to hunting the chickens inside the coop and would not go outside.

Similar to the rooster that would not die in the previous set of runs, there is a super hen at X=4 run, a super rooster at X=8 run, and a pair of rooster and hen at X=10 run that also would not die in this set of results. The situation at X=4 run is slightly different than that of the rooster because the hen could lay eggs that would hatch into chicks that might become hens which would lay more eggs and then the chicken population would become larger. This is somehow unrealistic because in the real world without the roosters then the eggs would not be fertilized, they would not hatch, and the super hen would die of old age or be eaten by the coyotes. Figure 5 shows the picture of the run that resulted in the super hen. The hen was about 2.5 years old while all of the coyotes were much younger, well below 1 year. The ages of the super hen and roosters of the runs at X=8 and X=10 were also much larger than those of the coyotes.

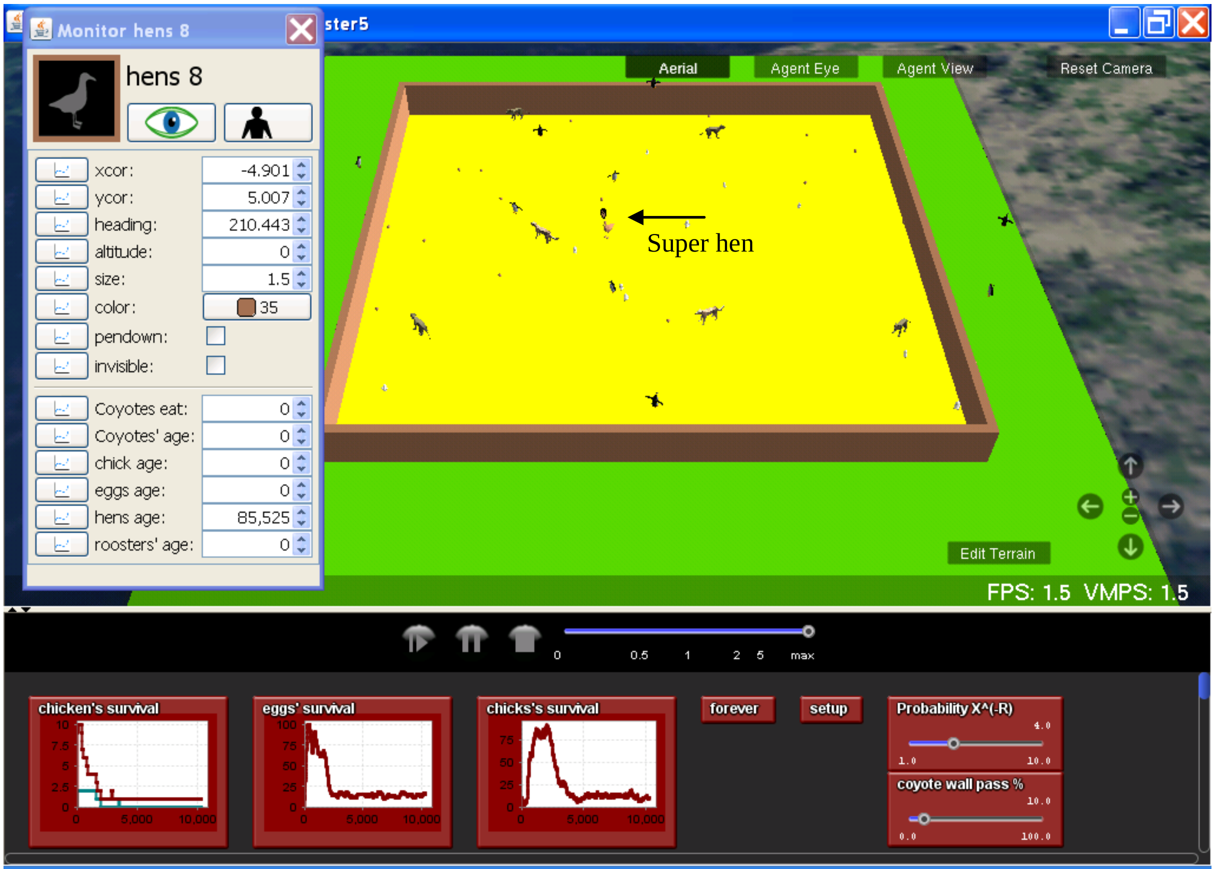

Figure 5. The super hen

For the third set of simulations, we varied the time unit from 100/day to 50/day, 24/day, and 10/day. The probability of the coyotes getting into and out of the coop was set at 40% and the X value was set to 1. We ran the time unit of 50/day simulation and it resulted in the death of all the eggs, chicks, and chickens. For the run with time unit of 24/day, which is 1 hour, the populations of the eggs, chicks, and roosters reached the limits in relatively short time, about 6 months. For the hens, there are a lot of ups and downs with the of the hen population hovering at about 15. We finally stopped the run believing that the hen population would just keep varying between 10 and 20. For the run with time unit of 10/day, the eggs, chicks, and chickens all reached their limits. Figure 6 shows the survival graphs of these three simulations.

Figure 6. Graphs of the surviving chickens, eggs, and chicks as a function of the time unit. The top one is for time unit of 50/day, the middle one is 24/day, and the bottom one is 10/day. The probability for a coyote to get into or out of the coop is 40% and X value was 1. The roosters are represented by the turquoise lines and the hens are represented by the brown lines in the leftmost graphs. Each unit of the X-axes represents about 5 time units.

We think that the reason for the chicken population surviving better with smaller time unit is due to the faster rate of the hens to lay eggs, eggs hatch into chicks, and chicks turn into chickens while the rate for the predators catching the chicks and chickens remain about the same.

Conclusion

We found that, with proper parameters, we can make a chicken survive an encounter with a predator. We also found that if we made a day about 100 units, the chickens would always end up dying, but if we made it 10 units, the chicken populations would be able to reach their limits and would become relatively stable. This means that to properly simulate a model, we would need both the correct parameters and very fine time unit. These requirements imply serious research and a very powerful computer such as the fastest super computer used by LANL.

References

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Chicks and Chickens by Gail Gibbons

Natural Resources: Farms

Most significant achievement

We learn how to program using the Starlogo TNG. It was the most fun to program games with Starlogo TNG and show them to friends. We also found a bug in the Starlogo TNG. In one of the simulations, while the code was running, we clicked on the chick survival graph to open a separate window that is larger in order to examine the graph in detail. Very soon we found that all the chicks were turning into crows and moved in 3 dimensions. They still however looked like chicks that fly.

Acknowledgements

We thank Mrs. Zeynep Unal, our GATE teacher and sponsor who helped us learn about Starlogo TNG and encouraged our efforts.

We also thank Dr. Duc Vo, our mentor, who helped us with ideas and programming.