# Behavior and Intelligence on Predator Prey Relationships
# TJHSST Senior Research Project
# Computer Systems Lab 2009-2010

Lenny Li

January 20, 2010


## Abstract

Simple predation prey simulations greatly simplify the problem by holding multiple variables constant, such as camouflage, predator vision, prey sensory, and other characteristics specifically attributed to the organisms involved. This project will analyze the consequence of ignoring the behavior and intelligence of prey in predator prey simulations. I will also compare the initial values that create a stable, oscillating ecosystem. I expect a model involving behavior and intelligence to be more accurate and longer lasting than a simple system.


**Keywords:** Predator Prey, Ecology, Agent Based Modeling, Intelligence

## 1 Introduction

This project involves writing a program that models a single predator, single prey system, where both the prey and the predator depend on a food source to survive. Both prey and predator asexually reproduce offspring with random attributes. In order for a stable predator prey system to exist, a small group of prey must escape the increasing predator population. That prey population must also reproduce slightly faster than the rate at which the predators die. This allows the predator population a chance to bounce back into survival, and the cycle continues–hypothetically. With a simple predator prey system, the prey will all die off from the predators. Since all the prey are equal, none will be able to escape predation. The predators will then quickly die off from starvation. In order for a stable ecosystem to exist between predator and prey, some prey must be intelligent enough to escape predation and reproduce to continue feeding the predators. This project will analyze the magnitude of the effect of incorporating behavior and intelligence into a simple predator prey simulation.

## 2 Background

There are a few permanent traits that most animals have. These include genetic traits (sex, size, etc.) and preferences (whether it likes brightness, darkness, cold, warmth, etc.) There are three main temporary factors to consider when an animal decides how to behave as well: hunger (should it eat?), libido (should it mate?), and fear (should it take evasive action?).

Two more complicated characteristics of the prey and predator are the Allee effect for the prey and prey choice for the predator. The Allee effect suggests that for smaller populations of prey, reproduction and chance of survival both decrease. This effect disappears as population size increases. There are two models to predict the food of predators. These assume that prey size and prey abundance are the only availability factors of importance to predators. One model suggests that the predator consumes prey as they are encountered, and the other assumes that predators feed to maximize energy intake. These, along with other general characteristics will have to be considered when writing the program and analyzing results.

In a perfect world, all prey and predators will have a radar system and know the exact positions of all enemies. Using this knowledge, each organism could hypothetically calculate heuristics and determine the best possible behavior. However, in a world with imperfect information, each prey will have to calculate the most favorable actions with the highest probability of benefiting. For example, it is probably not favorable for an animal to reproduce when its energy level is low.

## 3 Development

We start with an NxN map with P predators and Q prey. The predator feeds on the prey and the prey feeds on the food growing in the field. During each step, the predator searches for food, attempts at hunting a target, checks if it wants to reproduce, and finally moves a distance of one unit in a random direction. Each predator is able to see the circle of radius 3 units around itself and searches for food in that area. The prey searches for food, checks if it wants to reproduce, and then moves a distance of one unit in a random direction. Currently, the characteristics of newborns are randomly chosen, with the exception of location, but that may change. In the simple predator prey model, all probabilities are determined randomly, with no input from intelligence or prey abilities. In the first version of the behavior model, basic behavioral effects were considered. For example, all organisms were assigned a "skill" level. The higher that organism's "skill" variable was, the higher chance it had of a favorable outcome during an enemy encounter. Also, organisms were less likely to reproduce if their energy level was low than they were to reproduce with higher energy levels. This incorporates organism intelligence, as it would not be favorable to divide an already low energy level with an offspring. A possible future development would be making more intelligent moves which means stalking a prey or escaping a predator.

## 4 Tests and Analysis

Both programs were ran with the same initial N, P, and Q values. The graphs of population vs. time for both the simple model and the behavior model are shown in the appendix as Figure 1 and Figure 2 respectively. Multiple trials were ran, but they were mostly similar in outcomes. In the simple model, the predators immediately killed off all the prey and then died of starvation. In the behavior model, there were a few select stronger prey that survived from the initial predators. However, they could not reproduce fast enough to support the dying predator population, leading to a one organism system.

## 5 Discussion

We see that the behavioral model is closer to an oscillating stable predator prey system with minimal changes to incorporate behavior. It is already one period more accurate than the simple model. With more incorporation of behavior and probably some changes to allow the prey to reproduce quicker than the predators die, a more stable system may be created.

## References

[1] Andrew, Morozov, Petrovskii Sergei, and Li Bai-Lian. "Bifurcations and the Chaos in a Predator-Prey System with the Allee Effect." The Royal Society 11 Feb. 2004: 1407-1414. The Royal Society. Web. 23 Oct. 2009.

[2] Barney, Luttbeg, and Schmitz J. Oswald. "Predator and Prey Models with Flexible Individual Behavior and Imperfect Information." The American Naturalist 155.5 (2000): 669-683. JSTOR. Web. 14 Jan. 2010.

[3] Billard. "On Lotka-Volterra Predator Prey Models." Jstor: 375-381. Jstor. Web. 23 Oct. 2009.

[4] Griffiths, David. "Prey Availability and the Food of Predators." Ecology Summer 1975: 1209-1214. JSTOR. Web. 23 Oct. 2009.

[5] Oshanin, G., et al. "Survival of an Evasive Prey." Proceedings of the NationalAcademy of Sciences of the United States of America 106.33 (2009): 1-7. arXiv. Web. 14 Jan. 2010.

[6] Tu, Xiaoyuan, and Demetri Terzopoulos. "Artificial Fishes: Physics, Locomotion,Perception, Behavior." Association for Computing Machinery. N.p., July1994. Web. 14 Jan. 2010.

## 6 Appendices

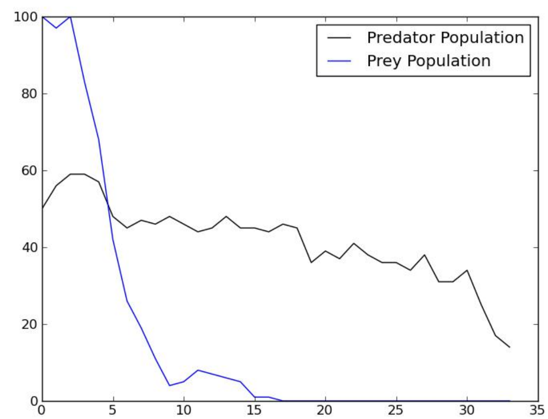


Figure 1: Figure 1. Population vs. Time of Simple Model

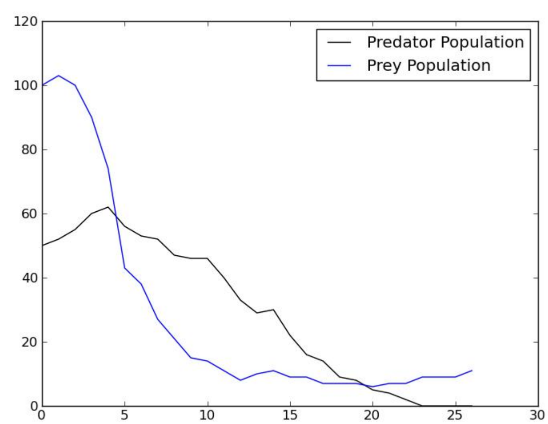


Figure 2: Figure 2. Population vs. Time of Behavior Model