

# Ant Foraging Simulation Analyzer (A.F.S.A)

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**Abstract-** An Ant Foraging Simulation (AFS) is an Agent Based Model (ABM) used to simulate ants foraging in environments that replicate field experiments. The AFS is used to quantify how information exchange between ants improves their foraging success so as to understand the fundamentals of social insect biology and lay a foundation for distributed computational search algorithms. To make logical sense of the data generated by an AFS, I designed a program using C++ that reads in the AFS data from a file and derives the necessary information needed to help us understand how the ants collect seeds from different distributions.

## INTRODUCTION

An Ant Foraging Simulation (AFS) is an Agent Based Model (ABM) used to simulate ants foraging in environments that replicate field experiments. The purpose of an AFS is to quantify how information exchange between ants improves their foraging success so as to understand the fundamentals of social insect biology and lay a foundation for distributed computational search algorithms. The Ant Foraging Simulation Analyzer (AFSA) is a command line program written in C++ to analyze the data generated by the Ant Foraging Simulation (AFS) program. It calculates the metrics for each colony size and reports the Mean and Standard Deviation of those metrics.

## Field Experiments

The AFS was designed based on field experiments conducted on three species of ants, native to North America. They are *Pogonomyrmex desetorum* with a colony size of 150, *Pogonomyrmex rugosus* with a colony size

of 250 and *Pogonomyrmex Maricopa* with a colony size of 1000.

In the field experiments, experimental seeds differentiated by their colors, are placed at different directions, within a specific radius from the nest of these species of ants. The colors used are red, purple and green. An equal amount of seeds is used for each color; the red seeds are placed in one pile at a certain distance, within a specific radius and direction from the nest. The purple seeds are divided into 4 piles and placed within the same radius as the red seeds but in different directions. The green seeds are divided into sixteen piles and placed within the same radius as the red and green seeds with regards to the ant nest but in different directions. The time it takes to collect the experimental seeds and other randomly distributed seeds is recorded, as well as the amount collected. From the data collected the Pile Seed Rate (PSR) and Recruitment Rate (RR) for each experimental seed including naturally occurring seeds are calculated.

## Automating the AFS

The AFS was initially designed to run just once, but to be able to carry out experiments that could not be carried out in the real world, it was modified to run as many times as we needed it to run.

## Pile Seed Rate

The pile seed rate shows the rate at which seeds are being collected from a certain pile. The formula for calculating the PSR is:  $PSR = \frac{\# \text{ of seeds collected}}{\text{Time taken to collect the seeds}}$ .

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## Recruitment Ratio

The Recruitment Ratio (RR) indicates which experimental seed pile the ants concentrated on more compared to the randomly distributed control seeds.

$$RR = \text{PSRe} / \text{PSRn}$$

Where:

PSRe=Pile Seed Ratio of Experimental seed,

PSRn= Pile Seed Ratio of Randomly distributed seeds.

## Calculating the Log Values of the Recruitment Ratios (RR)

Finding the Log values of the Recruitment Ratios to the base of 2 helps us to normalize the distribution and get a proper idea about how much of the experimental seeds the ants are collecting in comparison to the randomly distributed seeds in their environment.

### AFSA Algorithm

The data the AFS generates are the time stamps for each seed collected and brought back to the nest. Each value appears in this format: **1, 234**. The digit before the comma represents the seed and the remaining digits after the comma is the time in seconds it took to find and bring the seed to the nest.

1 represents the red experimental seeds,

2 represents the purple experimental seeds,

3 represents the green experimental seeds,

4 represents the randomly distributed seeds.

How the AFSA works:

1. Use a While loop to open and read each file that contains results of an AFS run.
2. Read the AFS values from their files into 4 array objects using another while loop, nested in the first while loop.
3. Use a Length function to determine how many seeds you have in each array. This tells us the number of individual seeds collected for a particular run.
4. Reset the Array Index to '0'.
5. Pass each Array into a function that converts the elements from string into integer.
6. After each array has been converted from string to integer, calculate the PSR. The PSR values are stored in arrays representing each seed, for each run.
7. Empty each array object so it can hold the values to be read from the next file.
8. Calculation of the PSR values of each run will stop once every file has been read. Note while each file is being read into the program, a counter is initialized to '0' and incremented as each file is read.
9. The RR value for each seed, for each run is calculated using a for loop and stored in an array for each seed. The length of each RR array is equivalent to the number of files read in.
10. A for loop is also used to calculate the log values to the base of two for each

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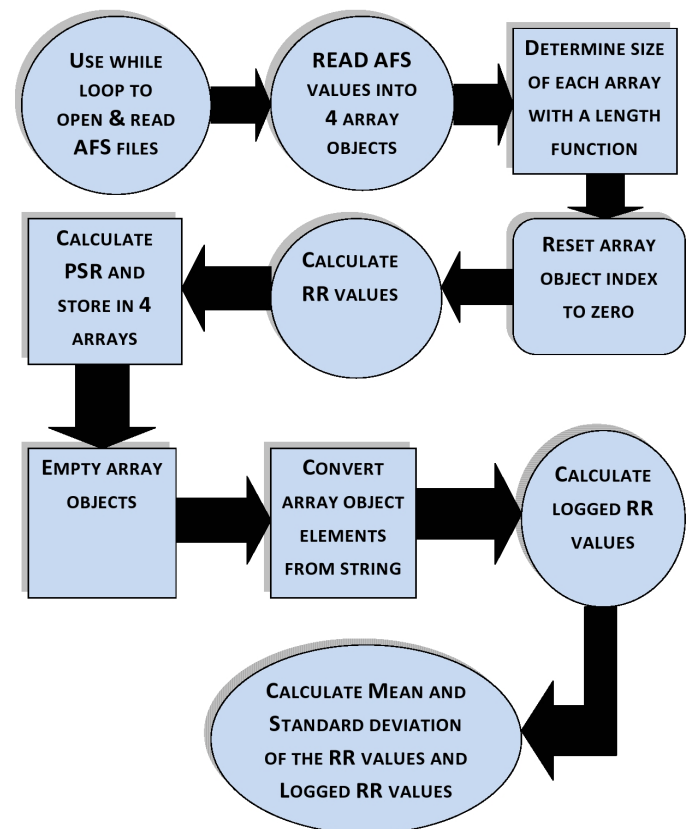
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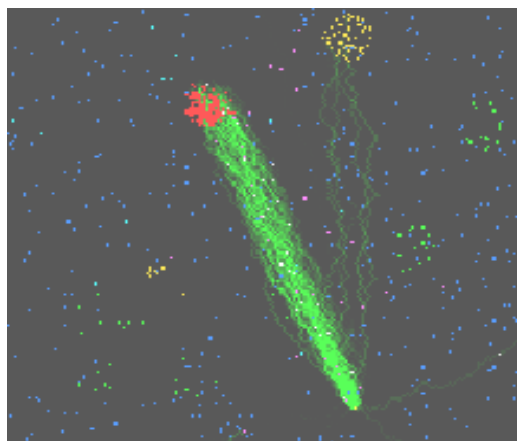
RR array. The results are also stored in an array.

collecting seeds en masse from the Red seed pile.

11. Now that we have our RR values for each seed, the mean and standard deviation are calculated with user defined functions for finding mean and standard deviation. The results are stored in variables and outputted to a file.
12. The PSR values, RR values and Logged RR values are also outputted to a file in a matrix form, using a for loop. In a matrix format, it is easy to export the file to a graphing program like MatLab and create a graphical representation of the data collected.



Ant Foraging Simulation (AFS) Screen Shot



The diagram above is a screen shot of the AFS simulation. The scatter blue dots represent natural occurring food.

In this screen shot we can see the ants (represented by the green irregular lines)

Diagrammatic Representation of AFSA Algorithm

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## RESULTS

### CASE 1

In carrying out these experiments for all 3 species, the seed pile sizes used were 32 and 256. The seeds for each run were randomly placed i.e. for each run, the seeds were placed in locations different from where they were in the previous run. For each pile size, for each of the three species, the distance of the experimental seeds from the ant nest, was the same. That is for Desertorum, when running the simulations for seed pile size 256 and 32, the distance of the seeds from the nests were the same.

**32 Seed Pile Size  
Logged RR Values Bar Chart**

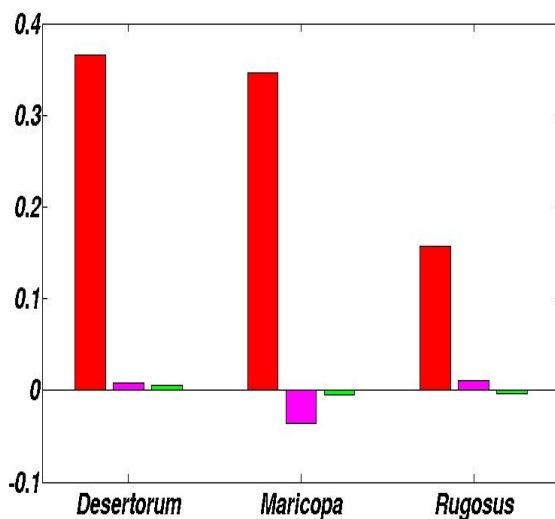


Figure 1

#### Keys

Red Seeds    Purple Seeds  
Green Seeds

### Desertorum

From Figure 1 we can see the Desertorum ants collected more of the experimental seeds compared to the randomly distributed seeds.

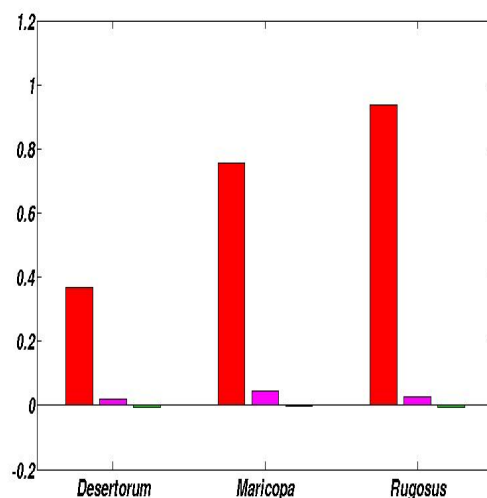
### Maricopa

From figure 1 we can see the Maricopa ants collected more of the red experimental seeds compared to the randomly distributed seeds, but less of the purple and green seeds compared to the randomly distributed seeds.

### Rugosus

From figure 1 we can see the Rugosus ants collected more of the red and purple experimental seeds compared to the randomly distributed seed. But less of the green experimental seeds compared to the randomly distributed seeds.

**256 Pile Size  
Logged RR Values Bar Chart**



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Figure 2

## Keys

Red Seeds Purple Seeds  
Green Seeds

## Desertorum

From Figure 2 we can see the Desertorum ants collected more of the red and purple experimental seeds compared to the randomly distributed seeds. While they collected less of the green experimental seeds compared to the randomly distributed seeds.

## Maricopa

From Figure 2 we can see the Maricopa ants collected more of the red and purple experimental seeds compared to the randomly distributed seeds. While they collected less of the green experimental seeds compared to the randomly distributed seeds.

## Rugosus

From Figure 2 we can see the Rugosus ants collected more of the red and purple experimental seeds compared to the randomly distributed seeds. While they collected less of the green experimental seeds compared to the randomly distributed seeds.

## CASE 2

In carrying out these experiments for all 3 species, the seed pile sizes used where 32 and 256. The seeds for each run were randomly placed i.e. for each run, the seeds were placed in locations different from where they were in the previous run. For each pile size, for all of the three species, the distance of the experimental seeds from the ant nest, were the same.

256 Seed Pile Size  
Logged RR Values Bar Chart

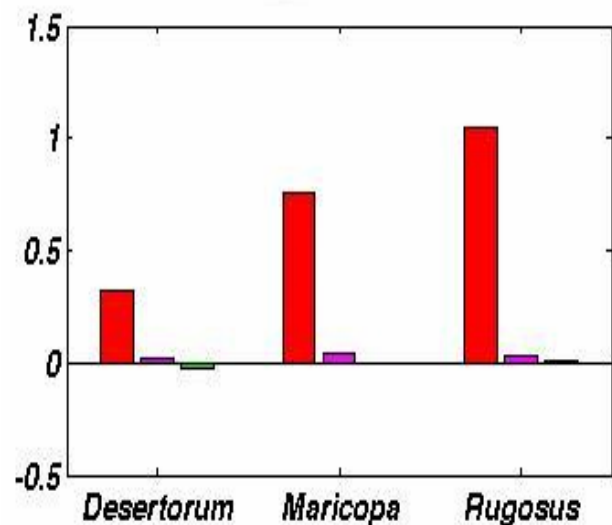


Figure 3

## Keys

Red Seeds Purple Seeds  
Green Seeds

## Desertorum

From Figure 3 we can see the Desertorum ants collected more of the red and purple experimental seeds compared to the randomly distributed seeds. But they collected less of the green experimental seeds compared to the randomly distributed seeds.

## Maricopa

From figure 3 we can see the Maricopa ants collected more of the red and purple experimental seeds compared to the randomly

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distributed seeds, but collected the green experimental seeds and the randomly distributed seeds at the same rate.

green experimental seeds compared to the randomly distributed seeds.

## Rugosus

From Figure 3 we can see the Rugosus ants collected more of the experimental seeds compared to the randomly distributed seeds.

## Maricopa

From figure 4 we can see the Maricopa ants collected more of the red experimental seeds compared to the randomly distributed seeds, but collected less of the purple and green experimental seeds compared to the randomly distributed seeds.

**32 Seed Pile Size  
Logged RR Values Bar Chart**

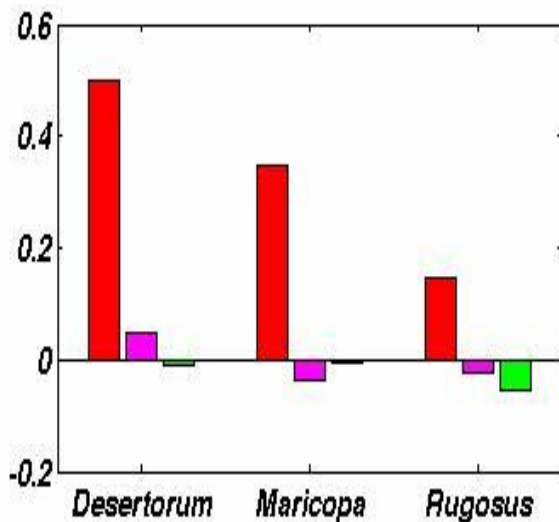


Figure 4

## Keys

Red Seeds    Purple Seeds  
Green Seeds

## Desertorum

From Figure 4 we can see the Desertorum ants collected more of the red and purple experimental seeds compared to the randomly distributed seeds. But they collected less of the

## Rugosus

From figure 4 we can see the Rugosus ants collected more of the red experimental seeds compared to the randomly distributed seeds, but collected less of the purple and green experimental seeds compared to the randomly distributed seeds

## Summary

The AFSA has proven to be a useful tool in understanding how the three species of ants on which the AFS was built on, forage for food.

Apart from being able to reproduce the results obtained in the real world; it can also be used to examine other possible real world scenarios run in the lab using the AFS.

The AFSA program can be easily applied to other Agent Based Models that study how organisms similar to ants, forage for food, with little to no changes to the source code.