Ant colonies

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Research Questions/Hypotheses

Initial Conditions

- What initial conditions lead to the propagation of the ant colony?

Exploration vs Exploitation

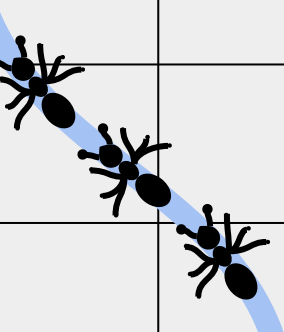
- Is there a critical level of exploration that maximizes foraging efficiency and/or colony survival?

Phase transition in organization of ants

- Is there a critical amount of ants that results in an organized society?

Self-organized criticality

- Is there self-organized criticality in the system when we introduce predators?



Model: Agents

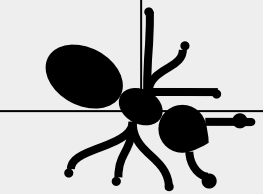
Ants

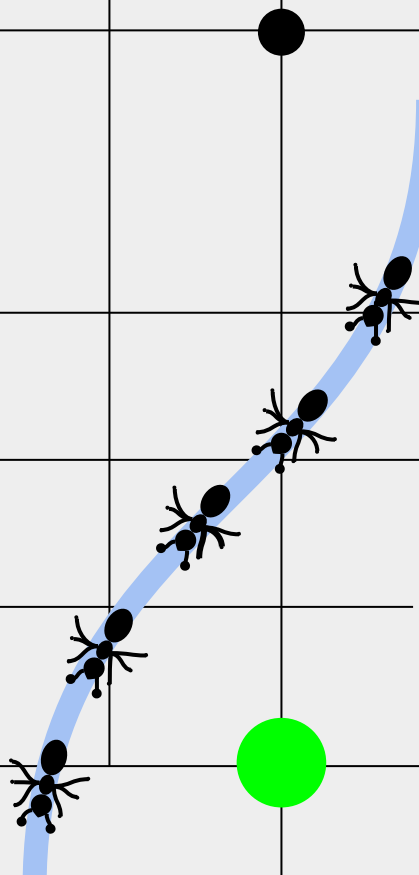
Home

Food

Pheromones

Predators



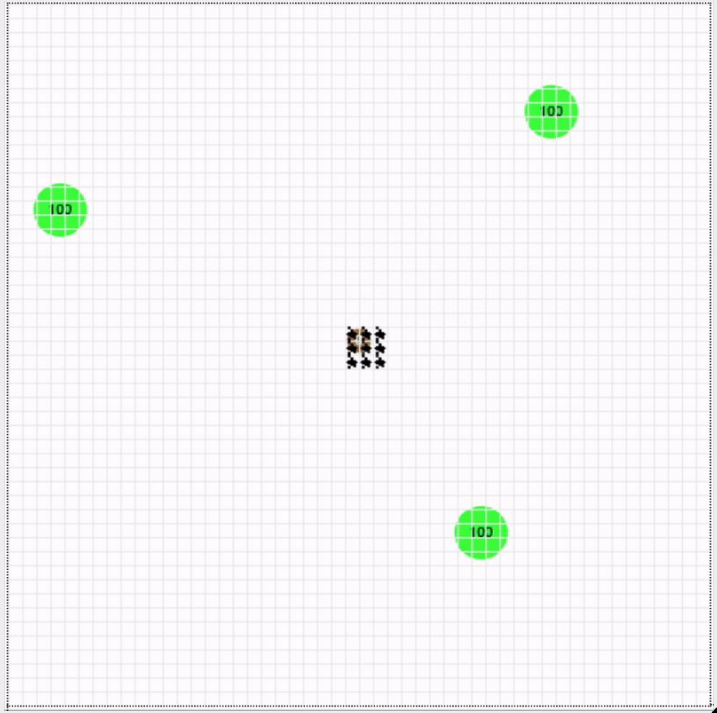


Model: Mechanisms

Birth & death
- Ants being born
- Ants dying (from starvation)
- Ants dying (from predation)

Foraging behaviour
- Exploring for food
- Eating food
- Transporting food

Communication & Environment
- Communication through pheromones
- Diffusion and evaporation



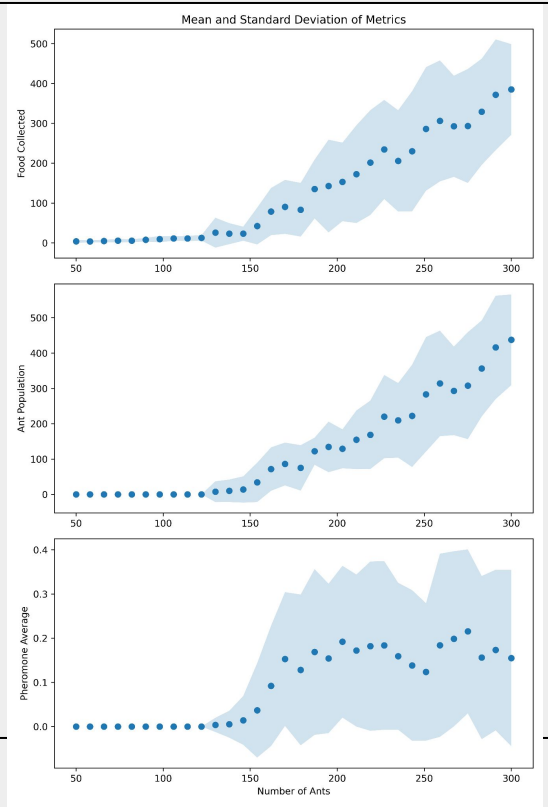
Initial Conditions: Number of Ants

Critical Transition: Around 150 ants, the system shifts from extinction to colony growth.

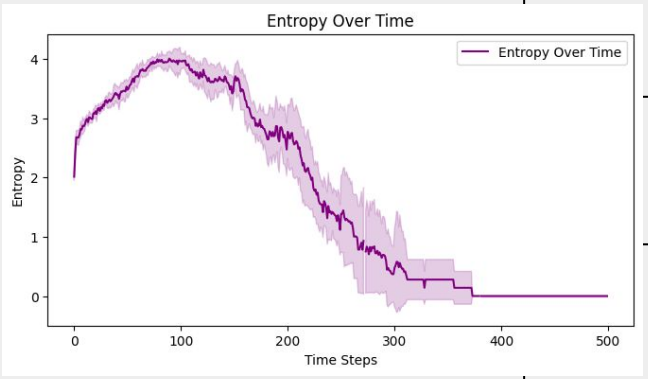
Food Collection: Increases with ant population but becomes more variable at higher numbers.

Pheromone Average: Stabilizes after the critical transition, indicating optimized foraging.

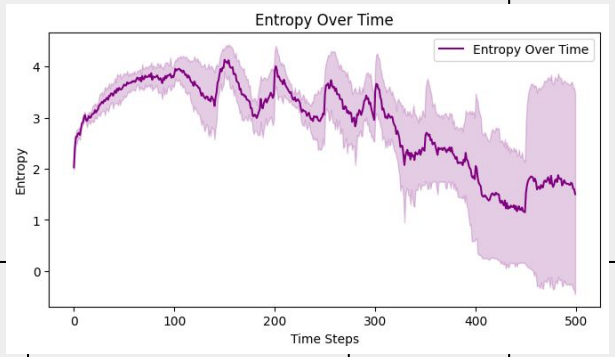
Entropy: Oscillations at higher values.



num_ants = 150



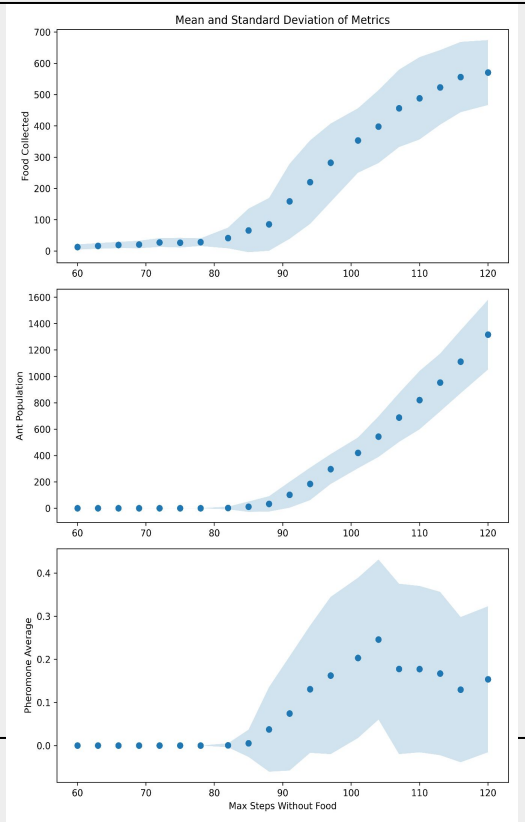
num_ants = 250



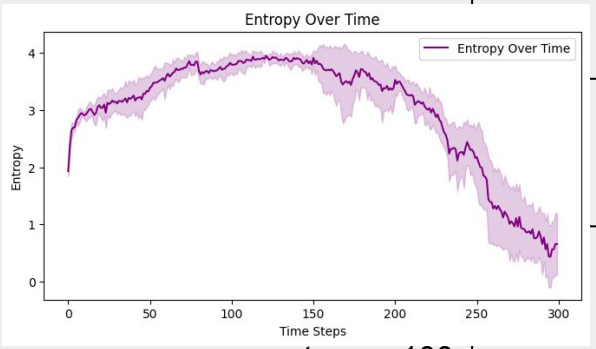
Initial Conditions: Max Steps without Food

Food Collection & Population: Longer survival without food increases resource collection and supports larger populations, with greater variability.

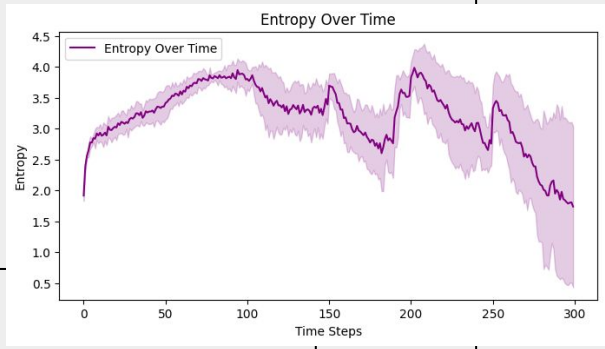
Self Organization: At higher values of the parameter, the ants are able to self organize (seen through the fluctuation of entropy in the system)



max_steps = 80



max_steps = 100

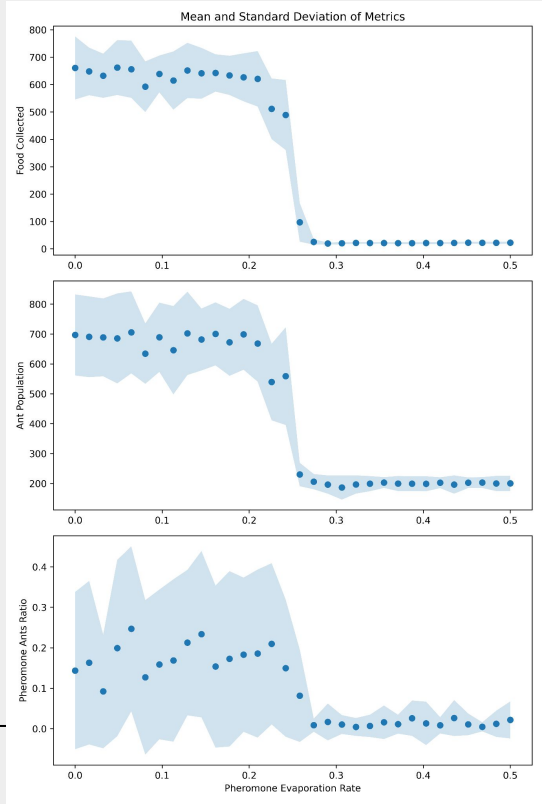


Initial Conditions: Pheromone Evaporation

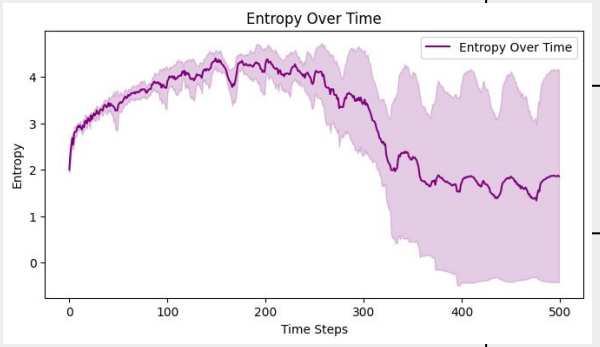
Evaporation Rate: At 0.2, the system transitions from efficient foraging to a collapse in food collection and ant population.

Pheromone Average: High evaporation rates reduce pheromone persistence, leading to decreased foraging efficiency.

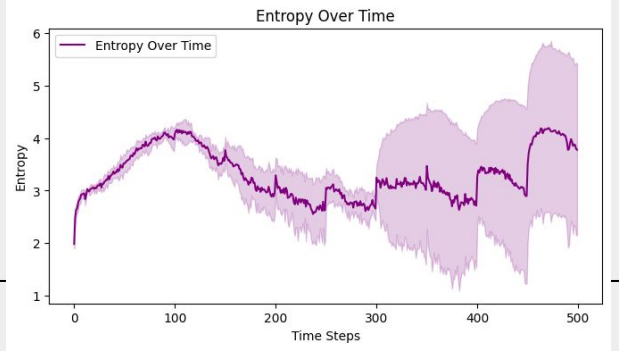
Sustained Population: Higher pheromone evaporation rate does not lead to the extinction of the colony but hinders population growth.



evaporate = 0.4

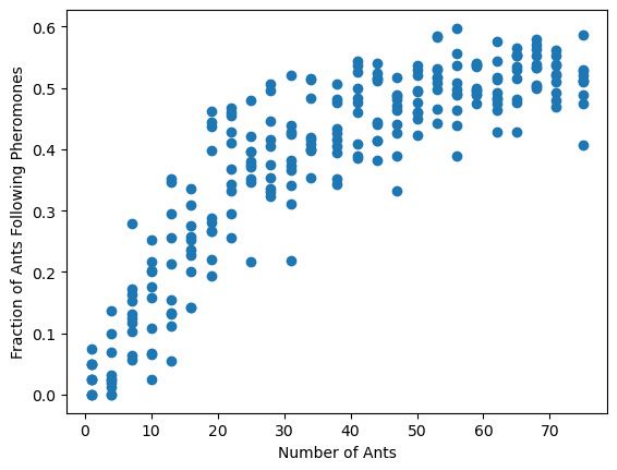


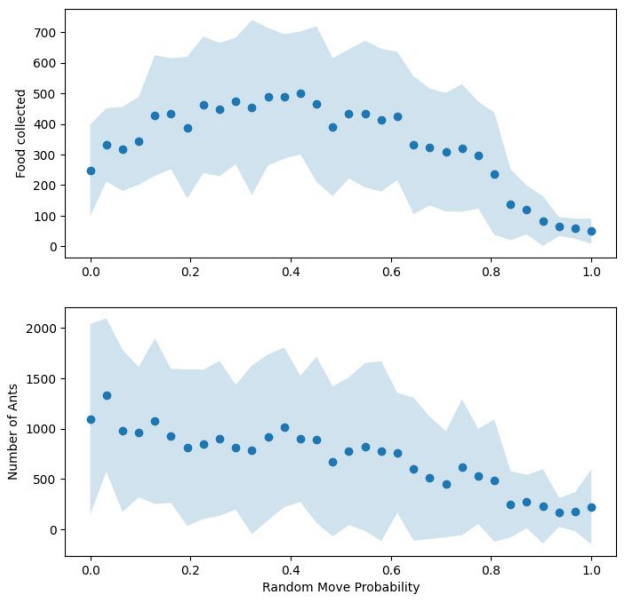
evaporate = 0.1



No Phase Transitions

- No phase transitions in organisation of ants
- No phase transitions in survival of colony when varying exploration parameter

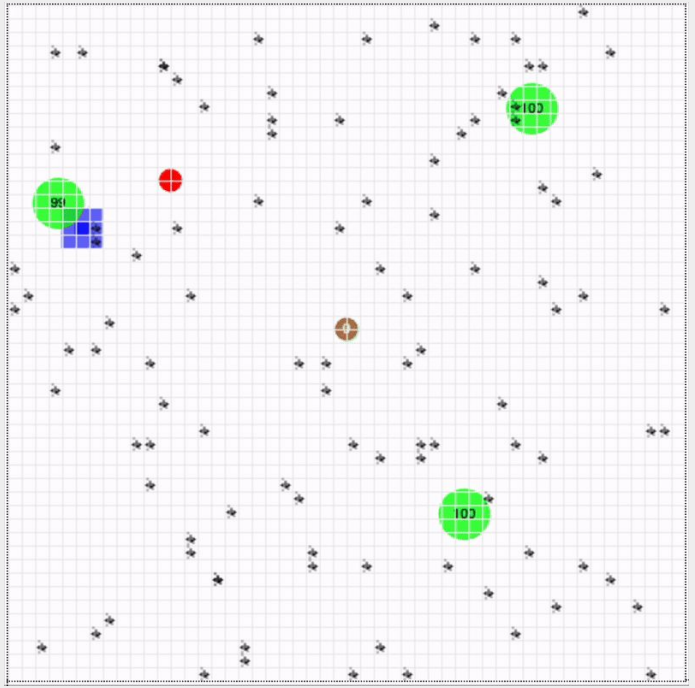




Introducing Predators

Rules:

- Predator spawns at **random** point
- Predator moves to neighbouring cell with the **maximum** number of ants
- Predator eats **one** ant from that cell
- Repeat until no more ants within the neighbourhood
- Meal size = **total number of ants consumed**



Predator Meal Size Distribution

Rules:

- Predator spawns at **random** point
- Predator moves to neighbouring cell with the **maximum** number of ants
- Predator eats **one** ant from that cell
- Repeat until no more ants within the neighbourhood
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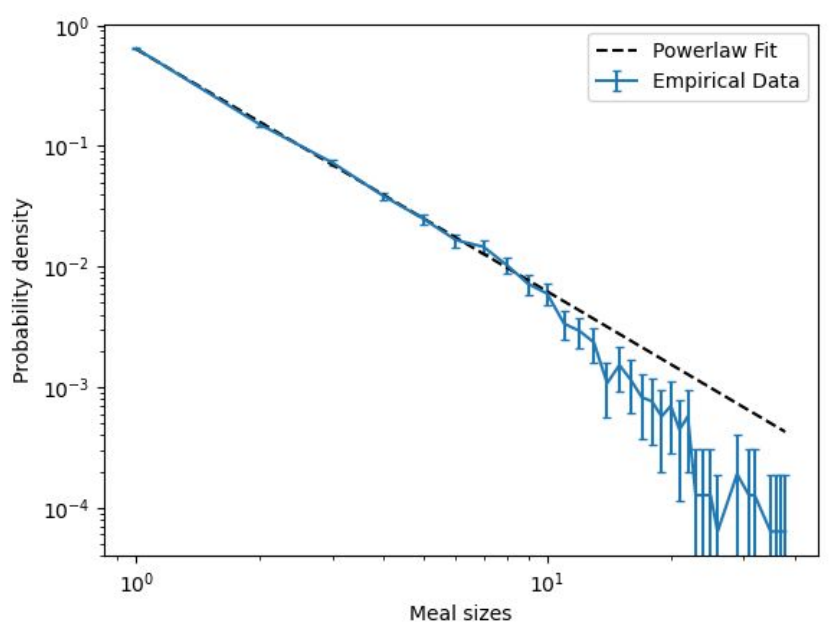


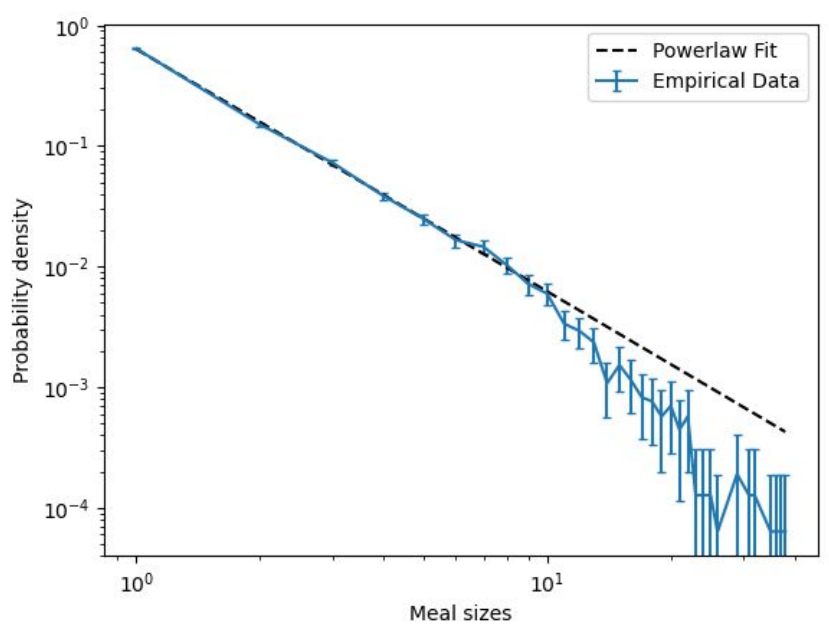
Predator Meal Size Distribution

Power law relationship observed!

Is this self-criticality?

Question: what features of the model drive this relationship?

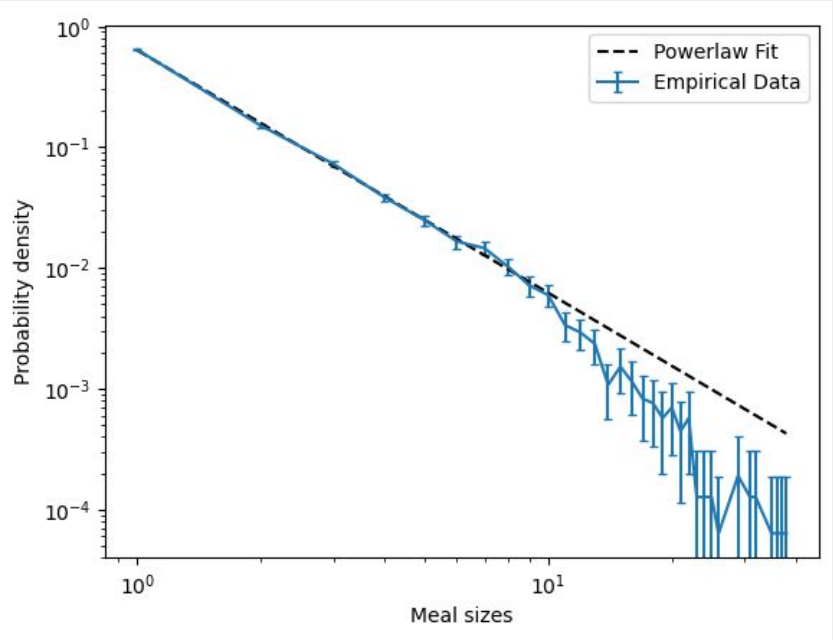
Idea: Change the model investigate how the power law changes.



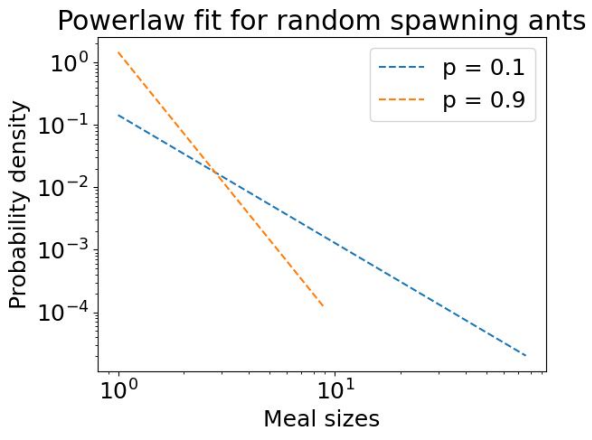
Self-Organized Criticality?

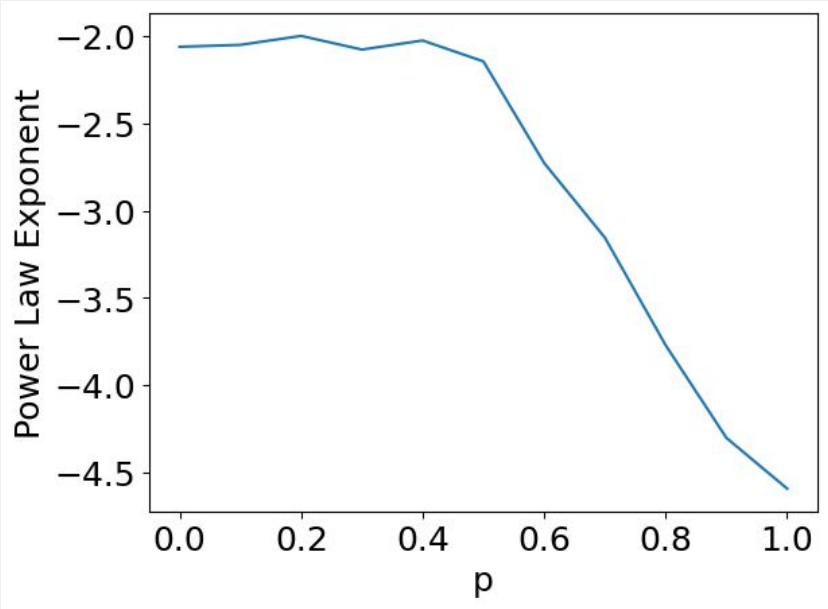
Ingredients

1. (Slow) build-up of stress
   i. ants being born
2. Intermittent release of stress
   i. ants being eaten
   ii. ants dying after not being able to find food
3. self-organization



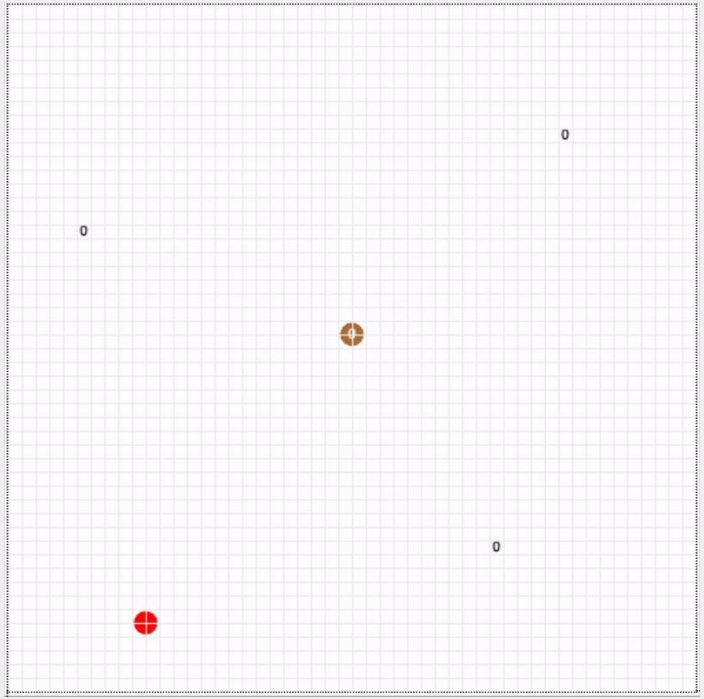
Varying The Exploration Parameter





Case 1: Remove Food and Nest

- No food
- No pheromones

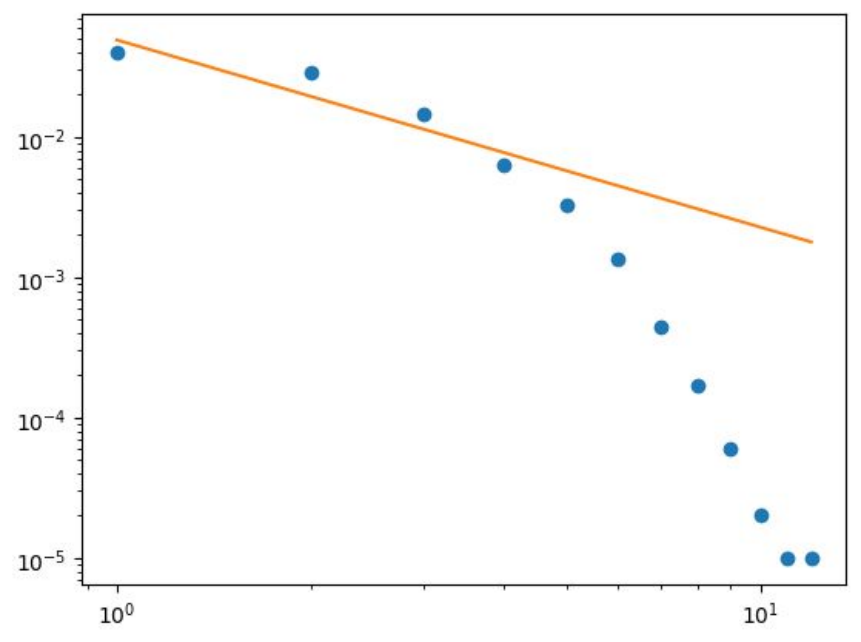


Case 1: Remove Food and Nest

No power law observed!

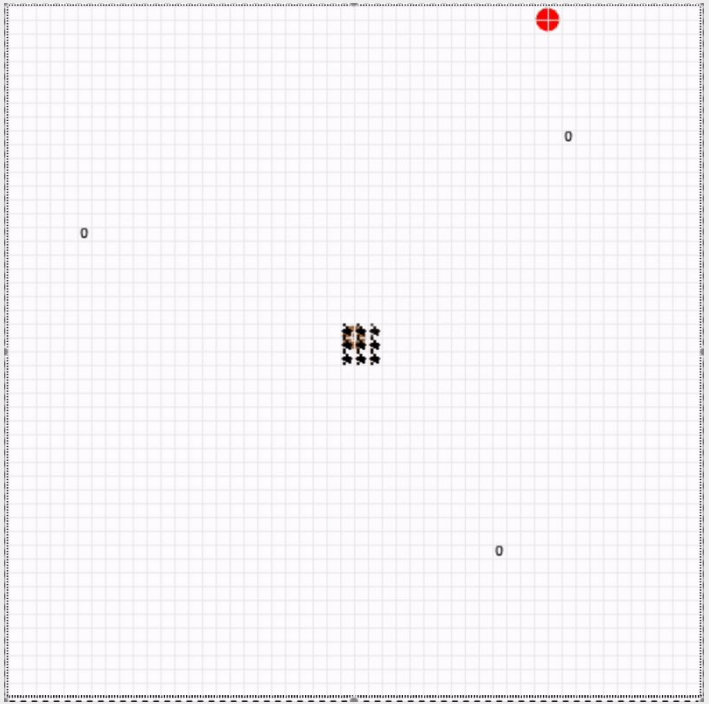
What has changed?

Ants no longer self organising



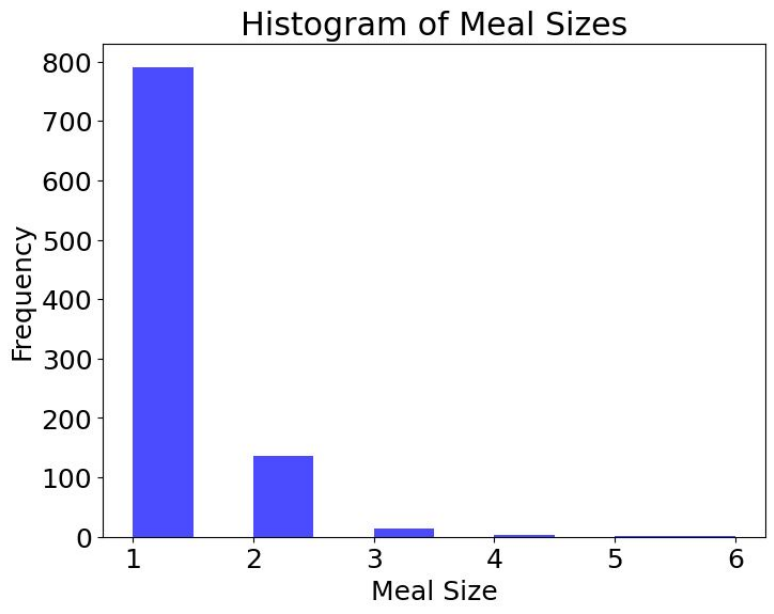
Case 2: Remove Food

- No food
- No pheromones



Case 2: Remove Food

No power law observed!



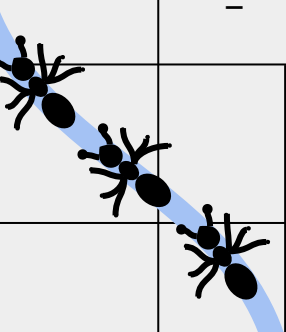
Summary

Initial Conditions
- Play a very important role in the dynamics of the system

Exploration vs Exploitation
- No phase transitions

Phase transition in organisation of ants
- No phase transition

Self-organized criticality
- The ant/predator dynamics exhibit self-organized criticality



Questions?

References

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