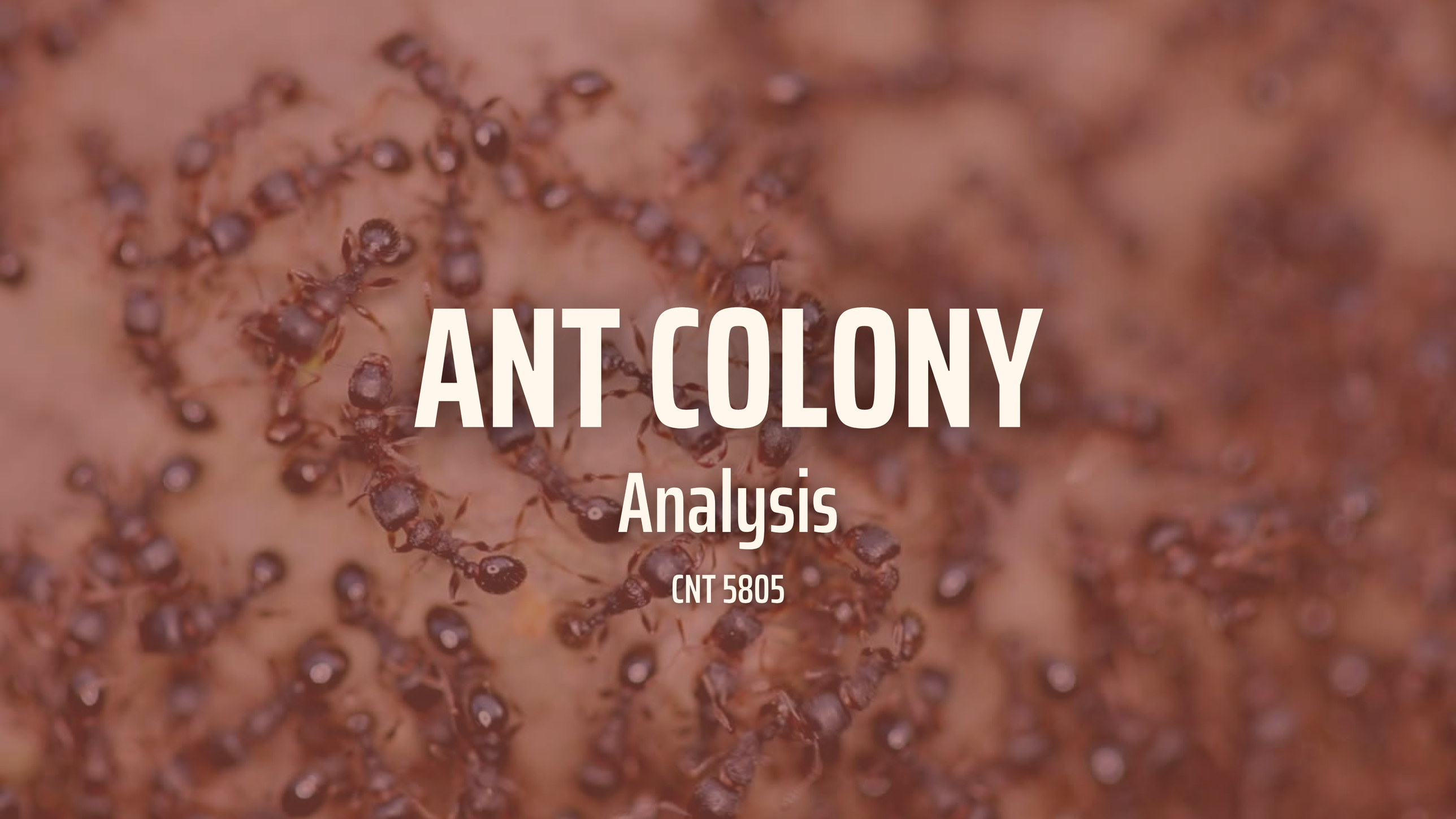


ANT COLONY

Analysis

CNT 5805

INTRODUCTION

Group #1

Noah Growney & Janny Velazquez

This project aims to analyze and compare the network structures of six different ant colonies. The motivation behind this research is to understand how ant colonies organize themselves and communicate within their social networks. By studying the network dynamics, we hope to uncover similarities and differences between the colonies, identify any distinct communities or subgroups within them, and investigate the roles of ants (e.g., foragers, cleaners, nurses) in information spread.

EXPLORATORY DATA ANALYSIS

Data Source

Mersch, Danielle P.; Crespi Alessandro; Keller, Lauren (2013). Data from: Tracking individuals shows spatial fidelity is key regulator of ant social organization [Dataset]. Dryad. https://datadryad.org/stash/dataset/doi:10.5061/dryad.8d8h7

Links & Nodes

Nodes: Ants
Links: Interactions between ants from one colony
*Number of Nodes and number of Links depends on the colony.
colony 1 day one had 113 nodes and 4451 links

Features / Fields

'colony'
'nb_foraging_events
'group_period4'
'nb_interaction_nurses'
'tag_id'
'visits_to_brood'
'nb_interaction_cleaners '
‘group_period1'
' 'body_size '
‘visits_to_nest_entrance '
'group_period2'
' nb_interaction_foragers'
'age.days.'
'group_period3'
'visits_to_rubbishpile'
'nb_interaction_queen'

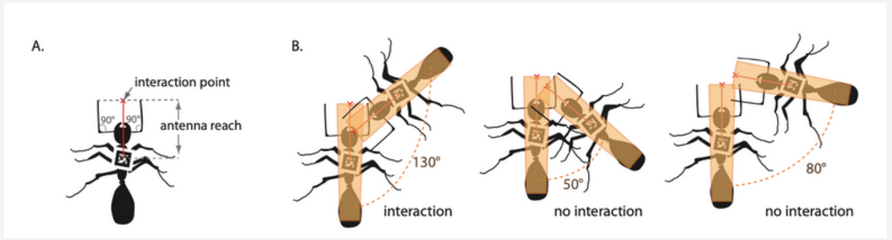
Weighted or Unweighted

Weighted

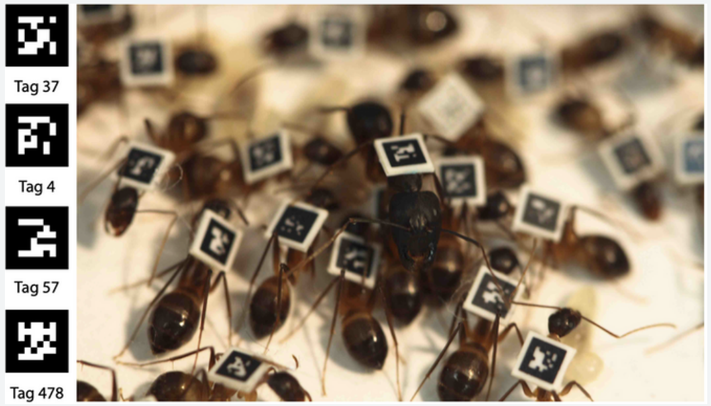
Directed or Undirected

Undirected

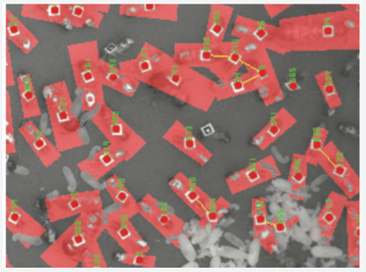
Interactions



Tagging



Example of ARTag markers and marked ants.
Photo by Dr. Joël Meunier.



RESEARCH QUESTIONS

1. What is the frequency of interactions among ants from the same colony

2. Do hubs exist within their own colonies? If so, what betweenness do those hubs exhibit?

3. How do the network structures of the six different ant colonies compare in terms of their overall organization?

4. Which specific ant roles (foraging, cleaning, nursing) play a crucial role in information spread within the ant colonies?

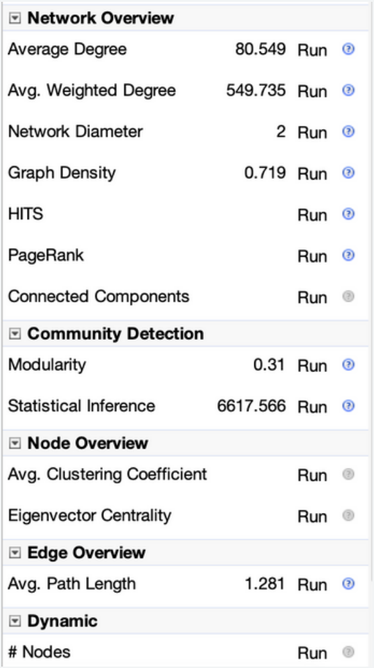
5. Can we identify distinct communities or subgroups within each ant colony's network?

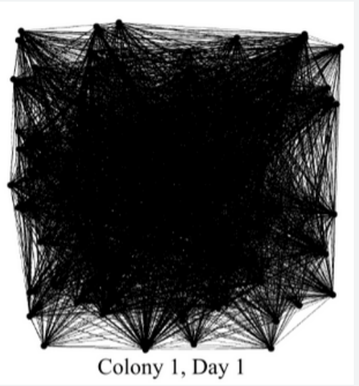
GRAPH OVERVIEW

key statistics of each colony on days 1, 15, and 40.

Colony	Day	Nodes	Edges	Avg. Degree	Diameter	Modularity	Density
1	1	113	4551	80.549	2	0.31	0.7192
1	15	99	3301	66.687	2	0.294	0.6805
1	40	55	1094	39.782	2	0.266	0.7367
2	1	131	6592	100.641	2	0.256	0.7718
2	15	111	3972	71.586	3	0.309	0.6506
2	40	58	895	30.862	3	0.314	0.2707
3	1	160	11140	139.25	2	0.213	0.8758
3	15	141	6403	90.823	3	0.34	0.6487
3	40	93	2853	61.355	3	0.272	0.6669
4	1	102	4270	83.725	2	0.19	0.8290
4	15	73	2144	58.74	3	0.225	0.8158
4	40	35	485	27.714	2	0.238	0.8151
5	1	152	9053	119.118	2	0.246	0.7889
5	15	133	5990	90.075	2	0.329	0.6824
5	40	66	1512	45.818	2	0.239	0.7049
6	1	164	10732	130.878	2	0.251	0.8029
6	15	143	7098	99.273	3	0.297	0.6991
6	40	91	2544	55.912	3	0.298	0.6212

key statistics of each colony on days 1, 15, and 40.

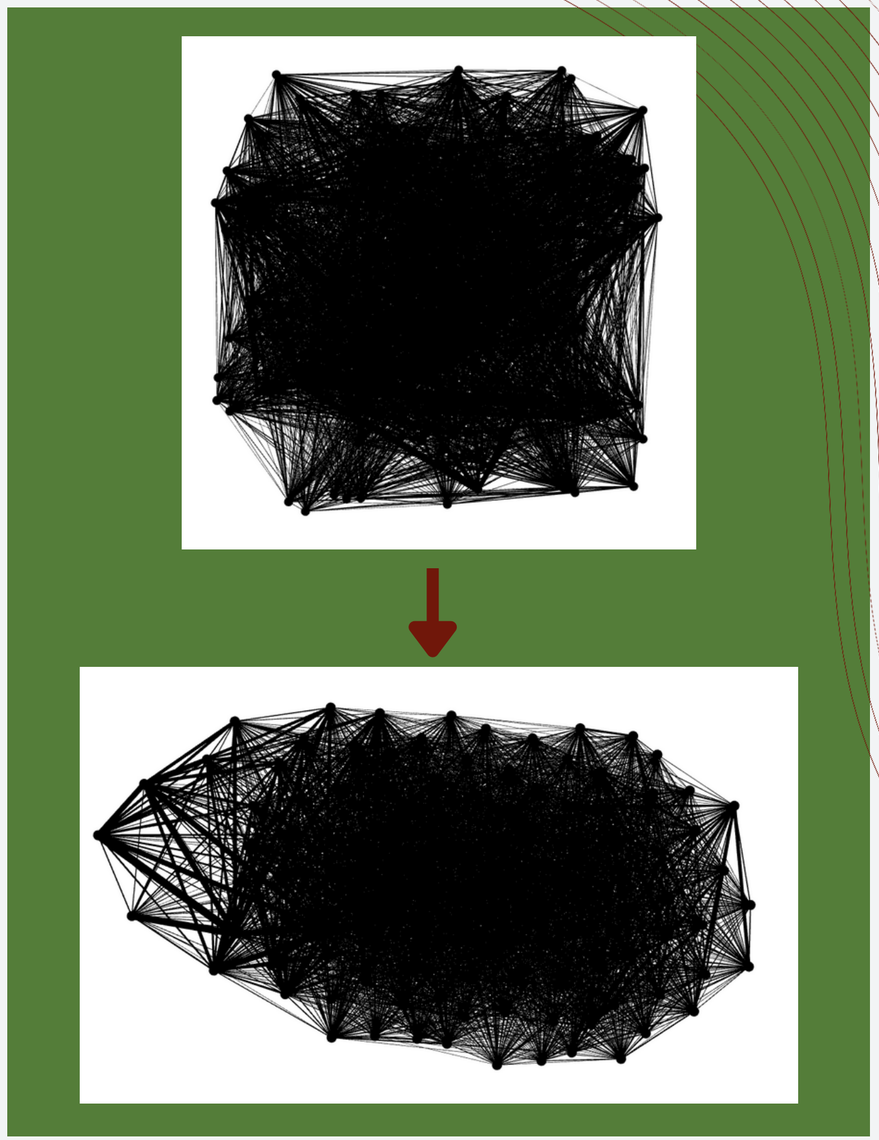



Colony 1, Day 1

The statistics provided above, and the graph provided both were obtained from the first colony on the first day. There are 113 nodes and 4551 edges. This colony has a high density and a high average degree. However, it does not seem to have any notable shape from an initial observation.

LAYOUT ALGORITHMS

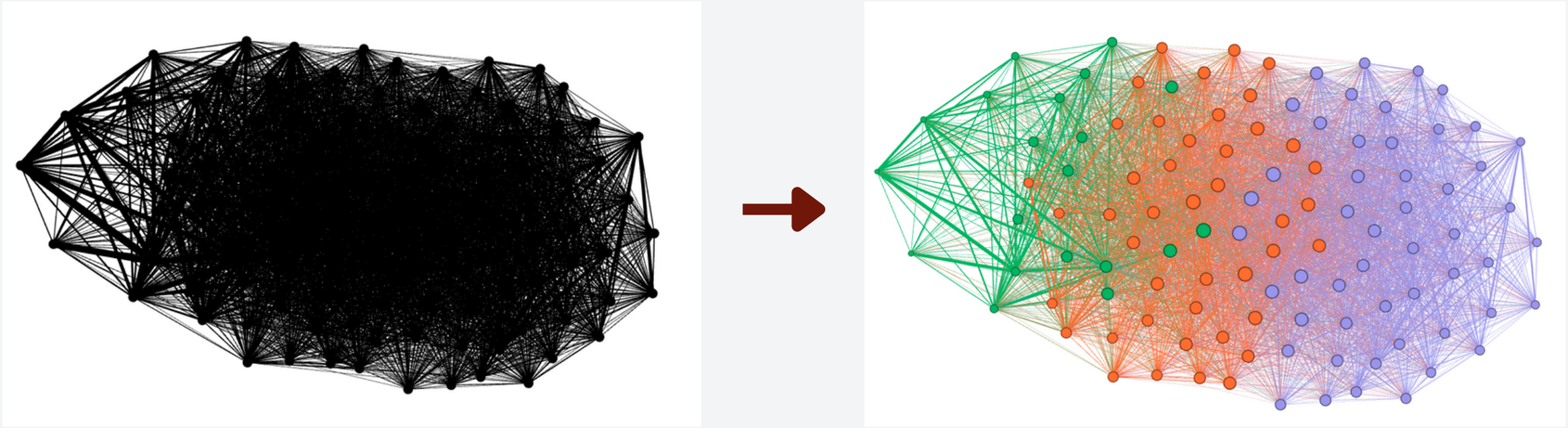
We chose the Fruchterman Reingold algorithm in Gephi with customized settings: Area=2000, Gravity=5.0, and Speed=1.0. This algorithm creates a clear and organized layout, resembling a physics system with nodes repelling and edges acting as springs. The larger area spreads out the network, gravity centralizes it, and a moderate speed ensures a balanced layout. This setup helps in identifying nodes with lower degrees around the edges, making it suitable for streamlined analysis.



Colony 1 day 2 before and after applying the layout algorithm

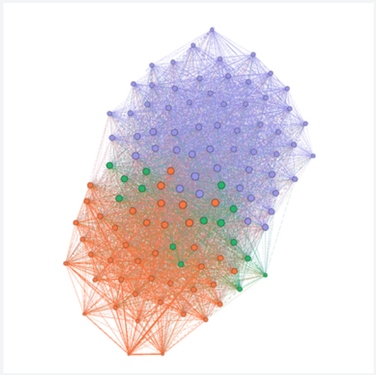
EMPHASIZING

We applied emphasis through strategic modifications. Node coloring was based on modularity, showcasing distinct communities within the network. Additionally, node sizes were adjusted relative to their degrees, highlighting highly connected nodes. This improved diagram offers a more detailed representation, with colors and labels revealing community structures, and varying node sizes emphasizing degrees of connectivity. These changes facilitate a deeper understanding of the network's dynamics and key relationships.

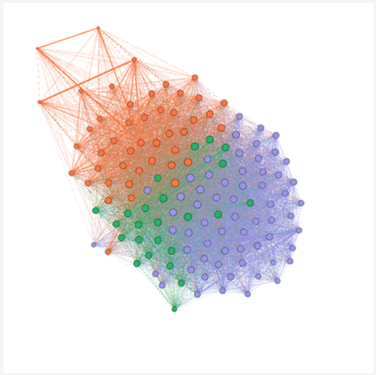


Colony 1 day 2 before and after emphasizing by coloring and adjusting node size

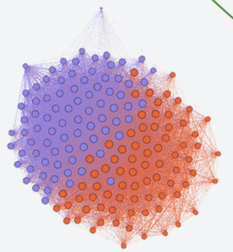
COLONIES 1-6 DAY 1



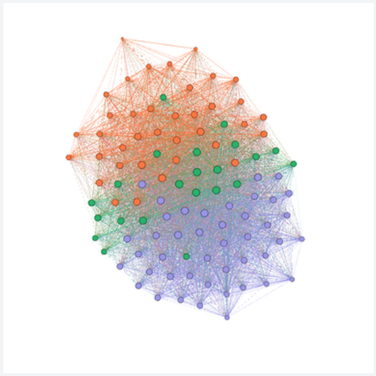
Colony 1 Day 1



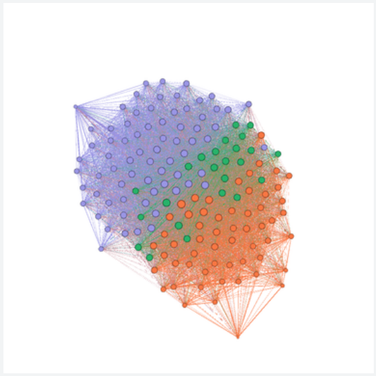
Colony 2 Day 1



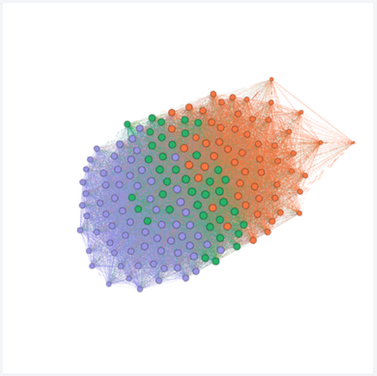
Colony 3 Day 1



Colony 4 Day 1



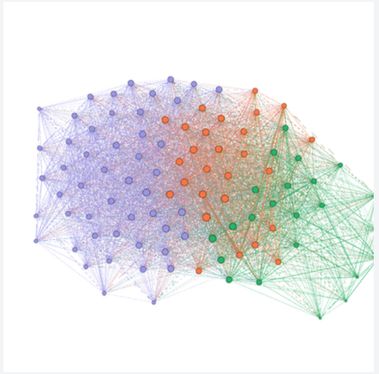
Colony 5 Day 1



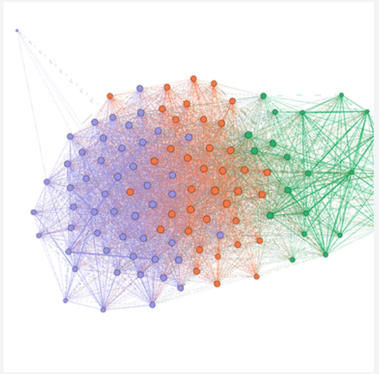
Colony 6 Day 1

Notably, each colony, except for Colony 3, displays a three-color scheme. The structural shapes of the colonies share a remarkable similarity. Colony 3 stands out with its nodes tightly compacted compared to the others. Additionally, in Colony 2, some nodes with lower degrees are notably positioned farther away from the rest of the nodes within the same colony. These observations provide valuable insights into the unique characteristics and connectivity dynamics of each colony.

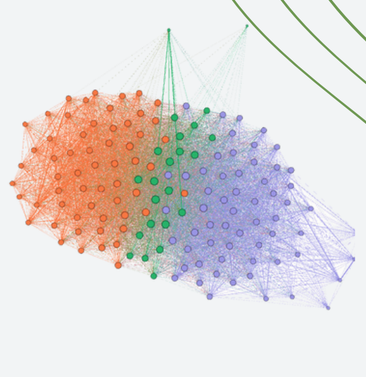
COLONIES 1-6 DAY 15



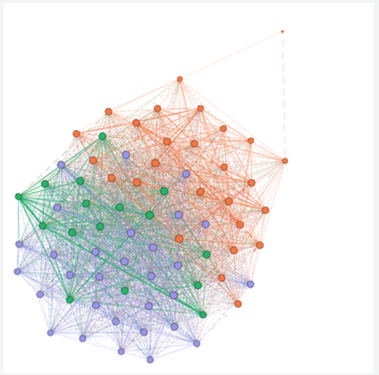
Colony 1 Day 15



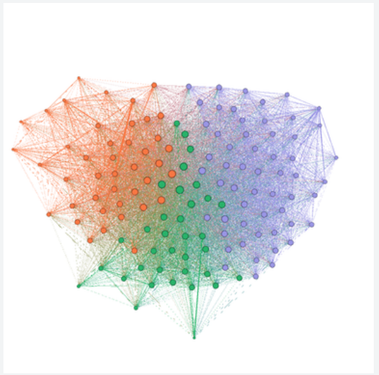
Colony 2 Day 15



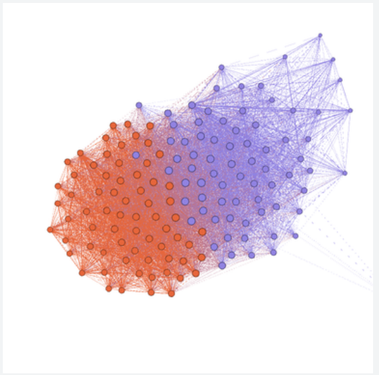
Colony 3 Day 15



Colony 4 Day 15



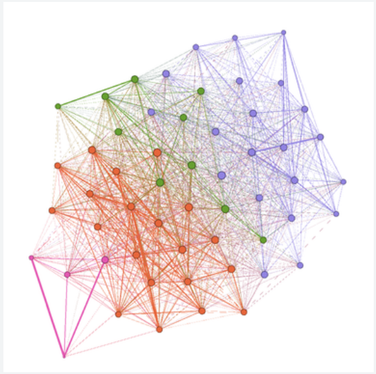
Colony 5 Day 15



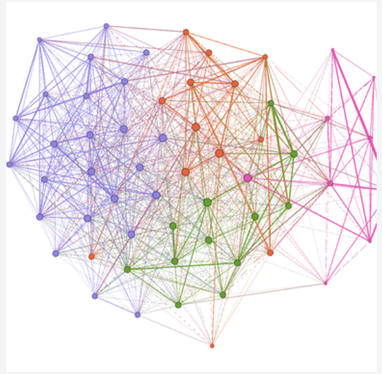
Colony 6 Day 15

On Day 15, with nodes color-coded by modularity, each colony exhibits three colors, with the exception of Colony 6. Notably, the shapes of Colony 4 and Colony 5 diverge significantly from the others, despite the uniform application of algorithms across all colonies. This intriguing disparity in shapes suggests unique structural characteristics within these particular colonies, adding depth to our understanding of their evolving dynamics.

COLONIES 1-6 DAY 40

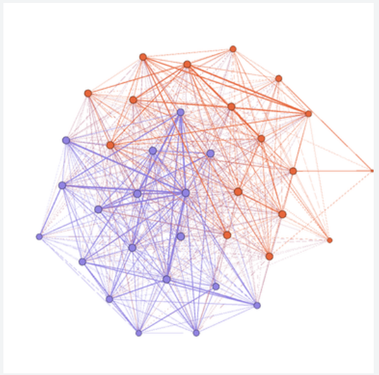


Colony 1 Day 40

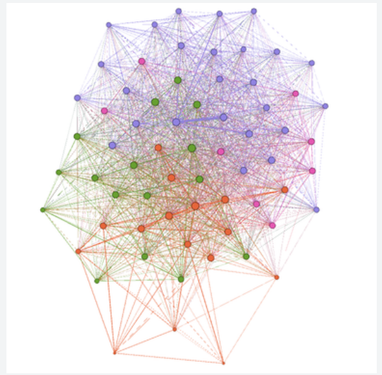


Colony 2 Day 40

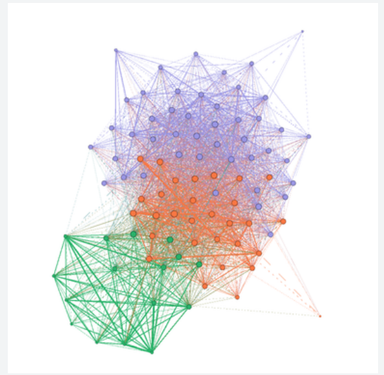
Colony 3 Day 40



Colony 4 Day 40



Colony 5 Day 40



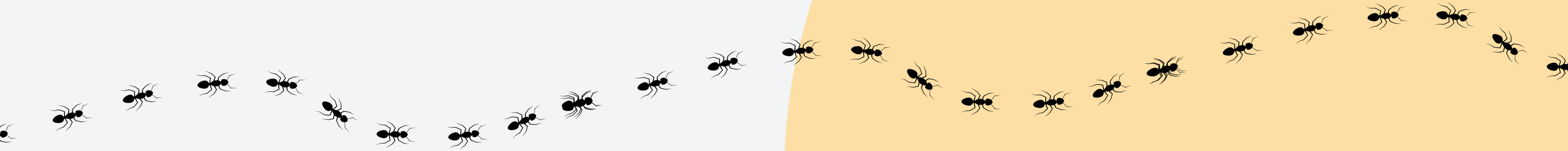
Colony 6 Day 40

On Day 40, Colony 1, Colony 2, and Colony 5 have more than three colors, a shift from previous days. Interestingly, Colony 4 is unique with only two colors on the final day. While Colony 3 and Colony 6 maintain their familiar shapes, Colony 1, Colony 2, Colony 4, and Colony 5 show noticeable changes in their structures. Notably, Colony 6's shape vividly illustrates three distinct communities, making it stand out as the clearest representation of evolving dynamics.

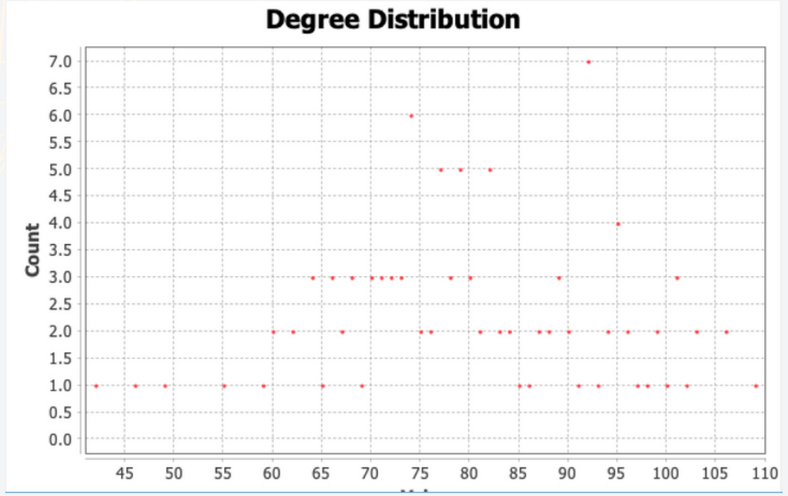
STATISTICS

- Colony densities varied, with Colony 4 having the highest overall average.
- On Day 1, Colony 3 led with a density of 0.8758 but decreased to 0.6669 by Day 40.
- Most densities ranged from 0.62 to 0.82, indicating moderate social network connectivity.
- On Day 40, Colony 2 had the lowest density at 0.2707, an outlier.
- Colonies 3 and 6 initially had high densities, correlating with the highest "Ants That Survived" percentages.
- Colony 4, starting with the lowest ant count, had the lowest survival rate.
- Modularity consistently ranged from 0.20 to 0.32, with few outliers.

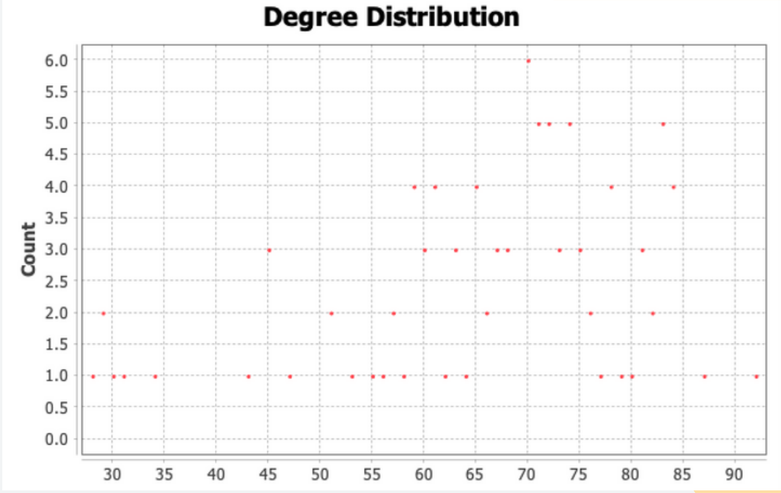
Ant Colony	% of Ants That Survived
1	48.67%
2	44.27%
3	58.13%
4	34.31%
5	43.42%
6	55.49%



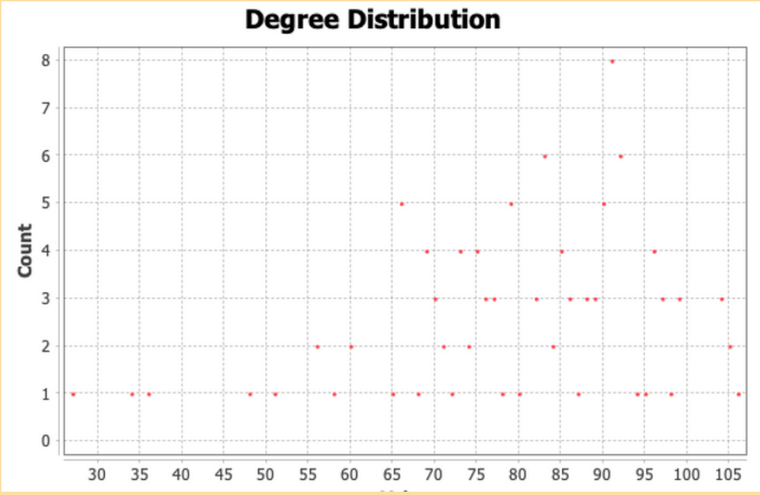
DEGREE DISTRIBUTION



Degree distribution of Colony 1, Day 1
Resembles more of a random network, rather than a scale-free network.

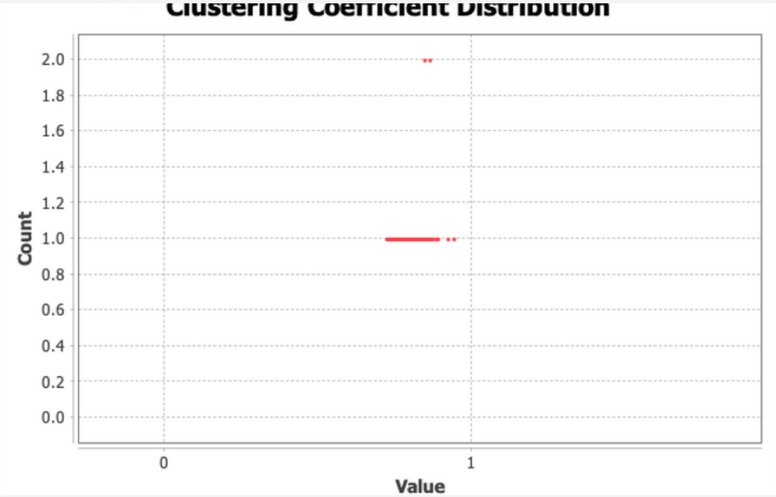


Degree distribution of Colony 1, Day 15
Also displays signs of a random network rather than a scale-free network.

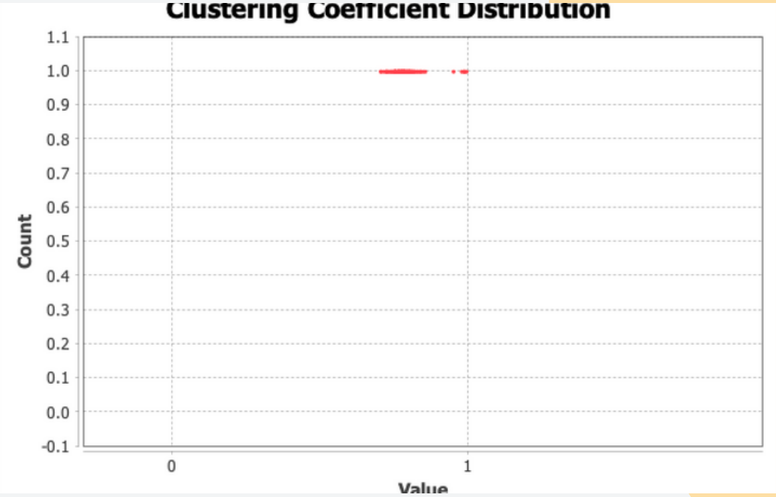


Degree distribution of Colony 1, Day 40
Still does not display signs of a scale-free network.

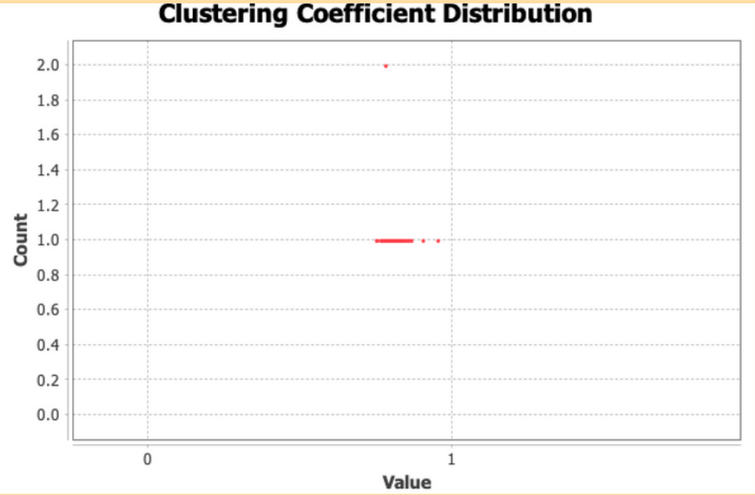
CLUSTERING COEFFICIENT DISTRIBUTION



Clustering coefficient distribution
of Colony 1, Day 1
The average clustering coefficient is
0.799 with not a lot of variation.

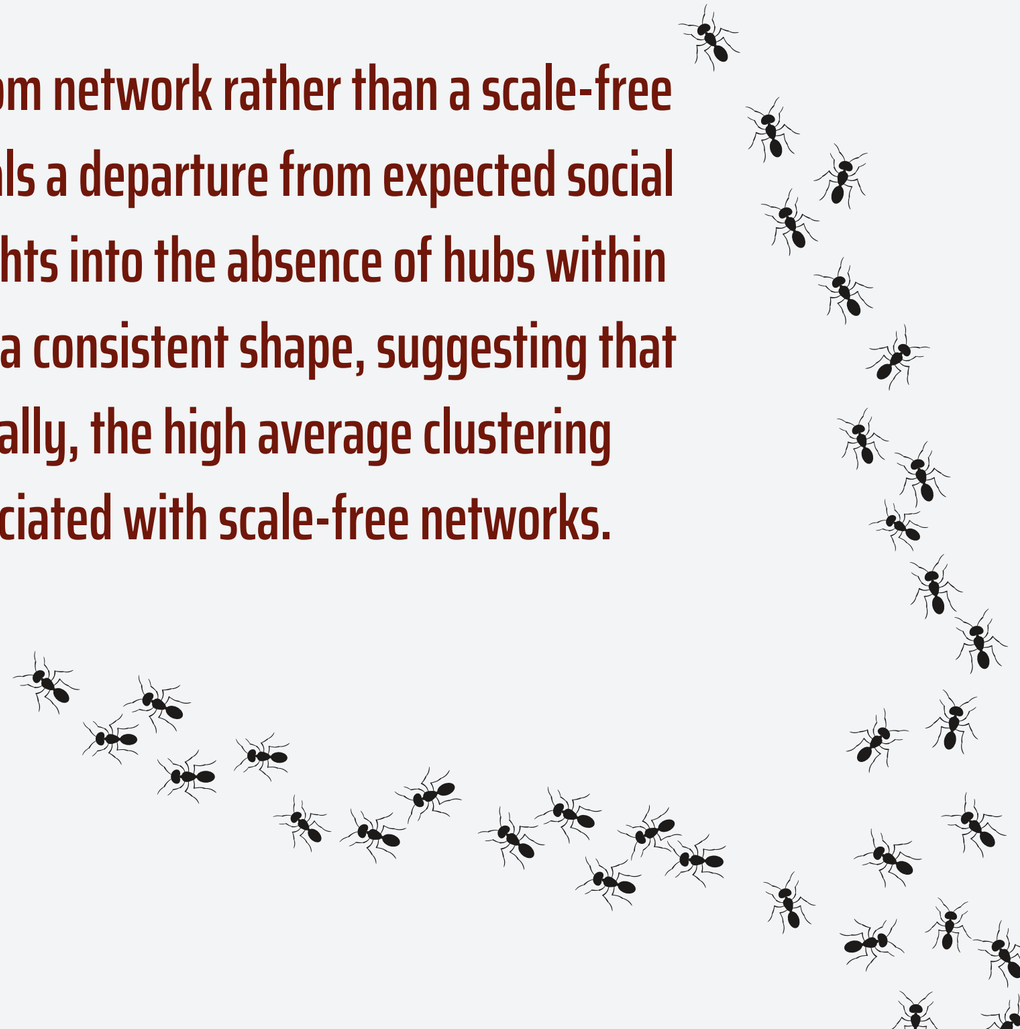


Clustering coefficient distribution
of Colony 1, Day 15
The average clustering coefficient is
0.786 with not a lot of variation.



Clustering coefficient distribution
of Colony 1, Day 40
The average clustering coefficient is
0.809 with not a lot of variation.

The observed degree distribution, leaning towards a random network rather than a scale-free one, significantly influences our research findings. It reveals a departure from expected social network patterns in ant colonies and offers potential insights into the absence of hubs within these colonies. Notably, the degree distribution maintains a consistent shape, suggesting that hubs do not spontaneously emerge over time. Additionally, the high average clustering coefficient aligns with the characteristics typically associated with scale-free networks.



FILTERS

The “Edge Weight” filter was applied. The min. edge weight was set to 10.
This allows for a clearer visual of the network as it thins out the edges that are not weighted as heavily as the others.

MISSING SCREENSHOTS

After applying this filter to Colony 1 on Day 1, 15, and 40, the output shows the orange group remaining highly connected whereas the other colors are less connected. This would indicate that ants of this color interact more frequently with one another than the other colors do.

RESULTS AND CONTEMPLATION

1	What is the frequency of interactions among ants from the same colony	The frequency of interactions among the ants was very high. This resulted in high-valued edges in the graphs that were displayed. When the filters were applied, some edges were taken away and there was a clear group that interacted with each other more than the other groups did.
2	Do hubs exist within their own colonies? If so, what betweenness do those hubs exhibit?	There were no hubs present in any of the colonies among any of the days.
3	How do the network structures of the six different ant colonies compare in terms of their overall organization?	The overall organization of the colonies was fairly consistent with there being about three distinct groups that information traveled through. The shape of the colonies was consistent, until the final day of the observation. The nodes were highly connected with one another, even between the three groups.
4	Which specific ant roles (foraging, cleaning, nursing) play a crucial role in information spread within the ant colonies?	The cleaners and the foragers were the two largest groups within the networks. The cleaners seem to play a larger role in the information spread within their own group and between groups as these ants were the ones that were usually apart of the group with larger-valued edges
5	Can we identify distinct communities or subgroups within each ant colony's network?	Each ant colony network seems to have three subgroups that relate to the social structure of ants, (Foraging, cleaning, nursing) with some variation. These subgroups do not act as traditional communities in Network Science terms, as there is a lot of interaction between groups.

DATA OPPORTUNITIES

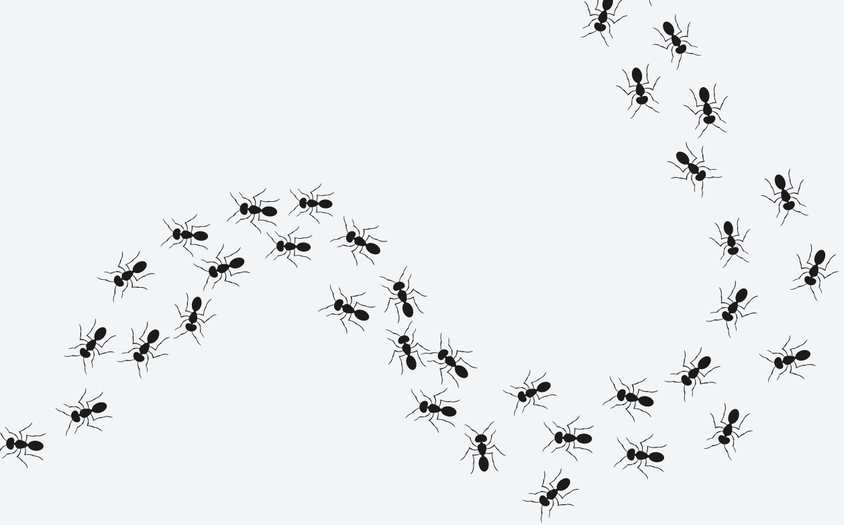
There are two keys insights that are missing from this data.

Insufficient temporal granularity in the data (e.g., one-hour intervals) limits analysis of information spread among ants.

Daily interaction data with large edge weights impedes detailed exploration of information diffusion dynamics

Lack of information regarding how ant colonies impact each other's networks.

Obtaining data on interactions between colonies could provide deeper insights into ant social dynamics and network behavior.



THANK YOU!