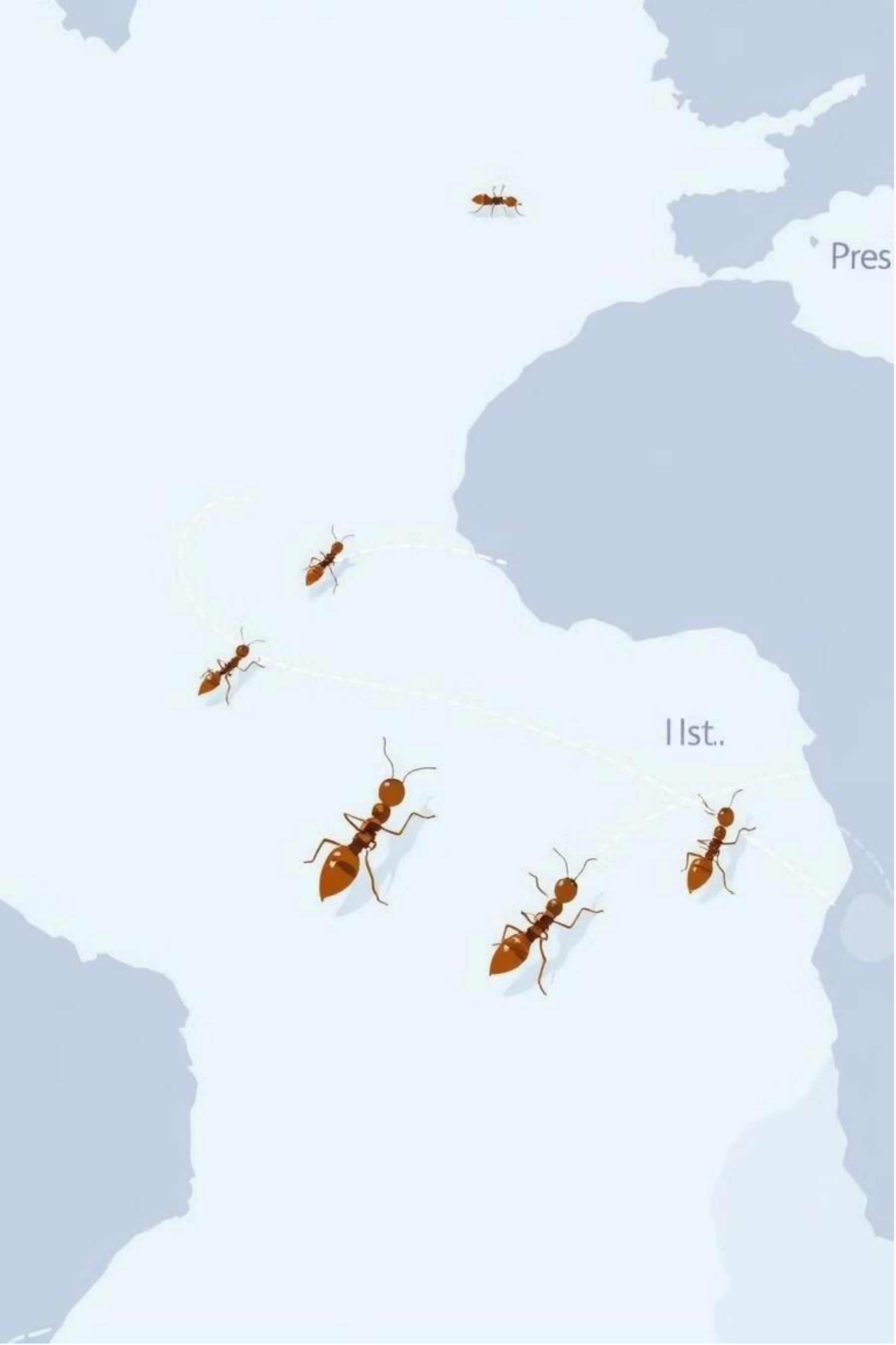
Ant Colony Optimization for the Traveling Salesman Problem

This presentation explores Ant Colony Optimization (ACO) applied to the Traveling Salesman Problem (TSP).



Introduction to TSP and ACO

Traveling Salesman Problem

Find the shortest route visiting all cities and returning to start.

Ant Colony Optimization

Simulates ants building solutions using pheromone trails and heuristics.

Process

Ants choose cities probabilistically; pheromones reinforce shorter paths.

Problem Setup and Distance Matrices

City Sets

Two sets: 10 and 20 cities with fixed random distances.

- Distances range from 3 to 50
- Same matrix used for all runs per set

Ant Colony Runs

Tested with 1, 5, 10, and 20 ants for 50 iterations each.

Best Paths and Costs Found

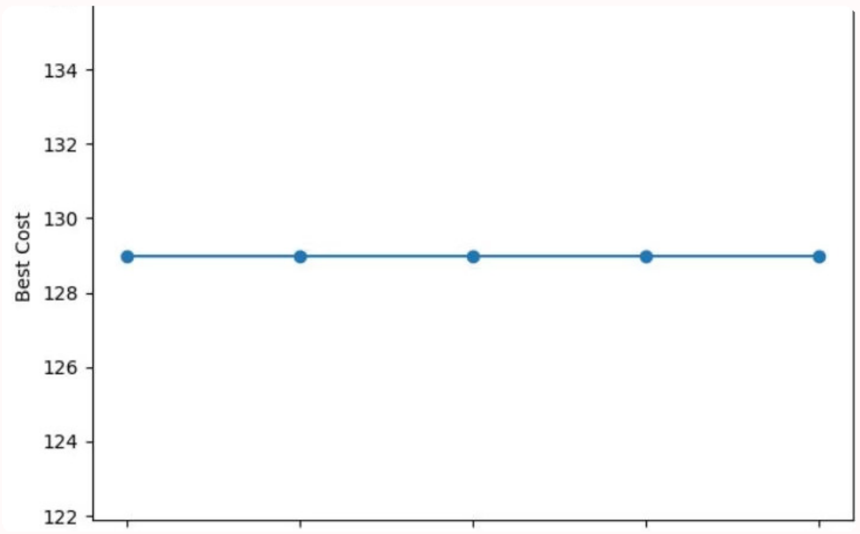
10 Cities

- Best cost: 124 with 5+ ants
- 1 ant cost: 129

20 Cities

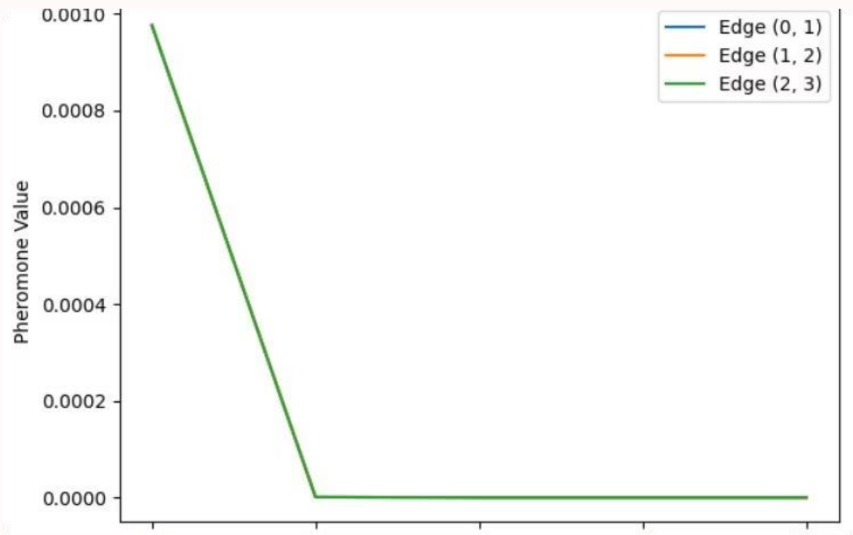
- Best cost: 248 with 10+ ants
- 1 ant cost: 256

10 Cities: Pheromone and Cost Trends



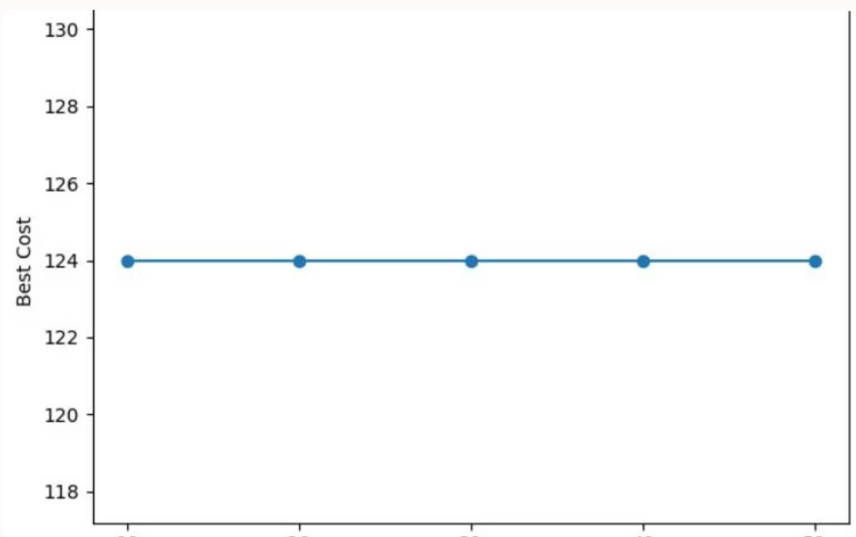
This plot shows that the best cost found by the ant stayed at 129 for all iterations. The solution was found early and did not improve further.

10 Cities, 1 Ant



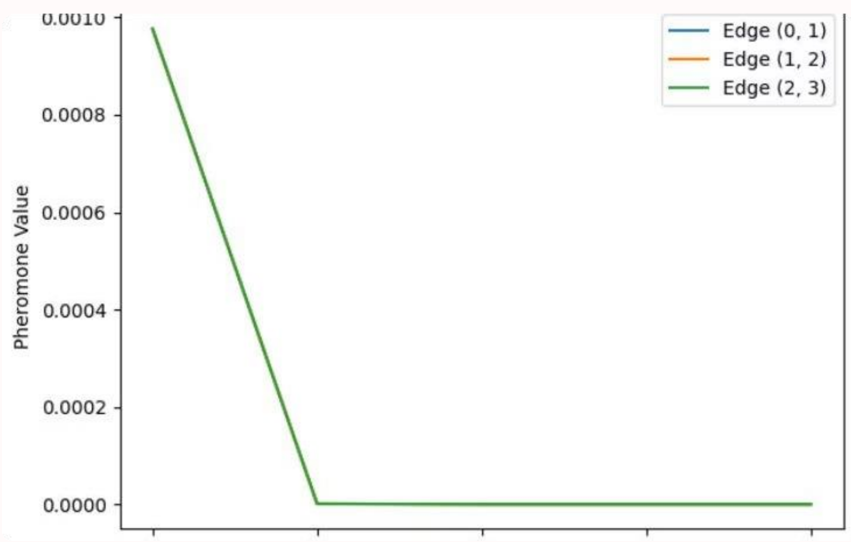
All selected edges quickly lost their pheromone, dropping to zero and staying there. This means these edges were not used in the best paths.

10 Cities, 1 Ant



This plot shows that the best cost found by the ant stayed at 124 for all iterations. The solution was found early and did not improve further.

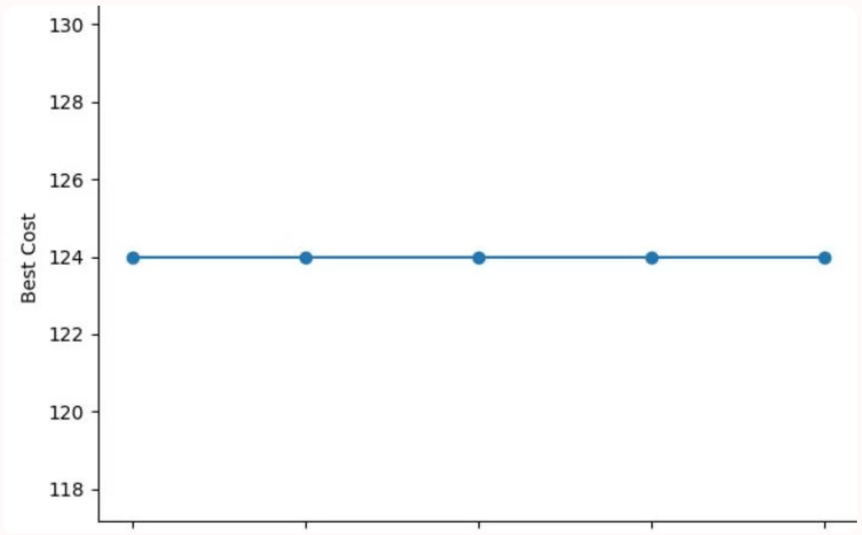
10 Cities, 5 Ant



All selected edges quickly lost their pheromone, dropping to zero and staying there. This means these edges were not used in the best paths

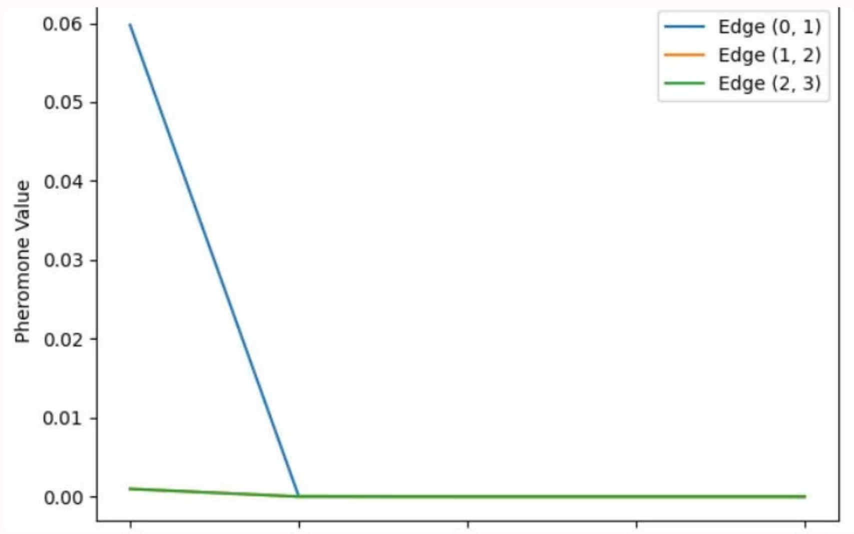
10 Cities, 5 Ant

10 Cities: Multiple Ants Pheromone and Cost



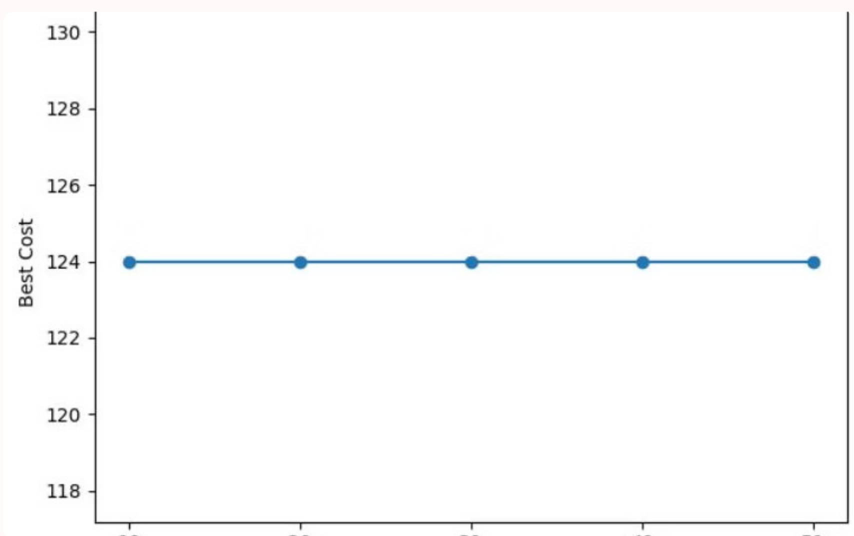
This plot shows that the best cost found by the ant stayed at 124 for all iterations. The solution was found early and did not improve any further.

10 Cities, 10 Ant



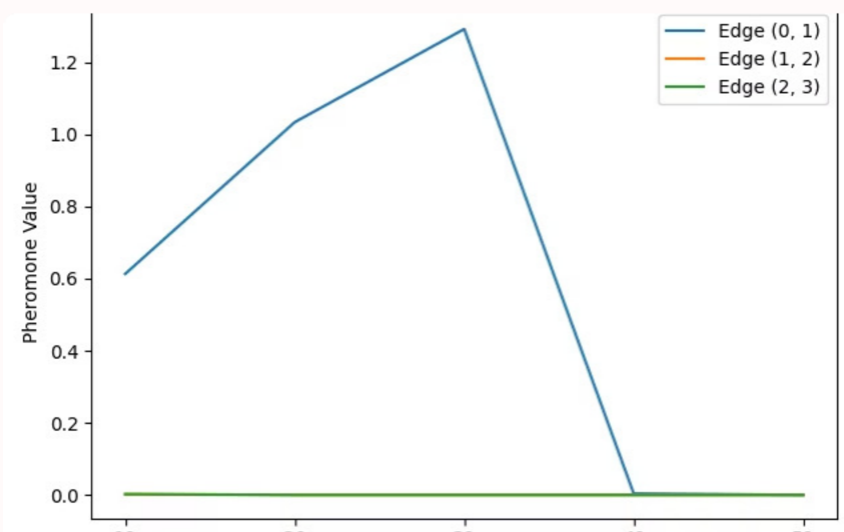
The pheromone on edge (0, 1) and (2, 3) quickly dropped to zero and stayed there, showing these edges were not used in the best solutions. Edge (1, 2) was never used.

10 Cities, 10 Ant



This plot shows that the best cost found by the ant stayed at 124 for all iterations. The solution was found early and did not improve any further.

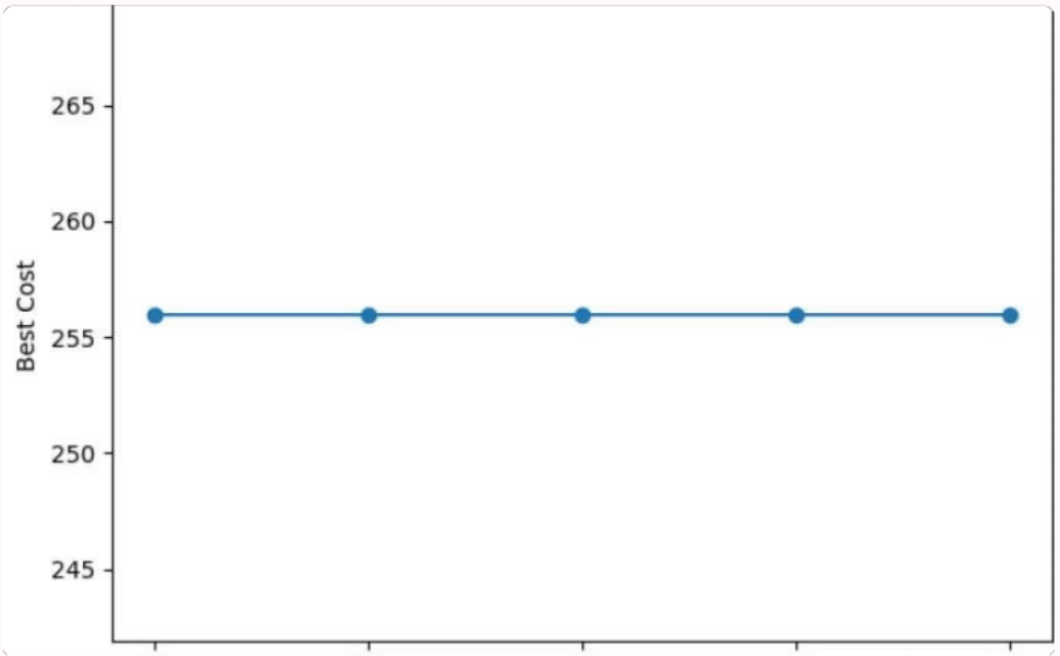
10 Cities, 20 Ant



The pheromone on edge (0, 1) increased at first, then dropped to zero, meaning it was used in good paths early but not later. Edges (1, 2) and (2, 3) were not used

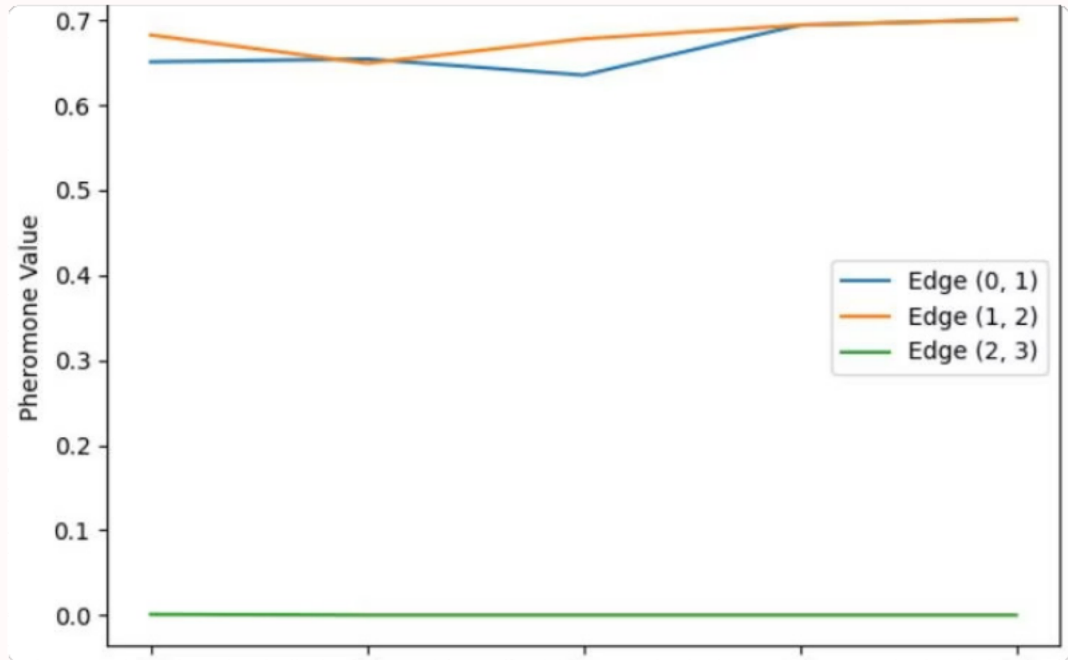
10 Cities, 20 Ant

20 Cities: Pheromone and Cost Trends

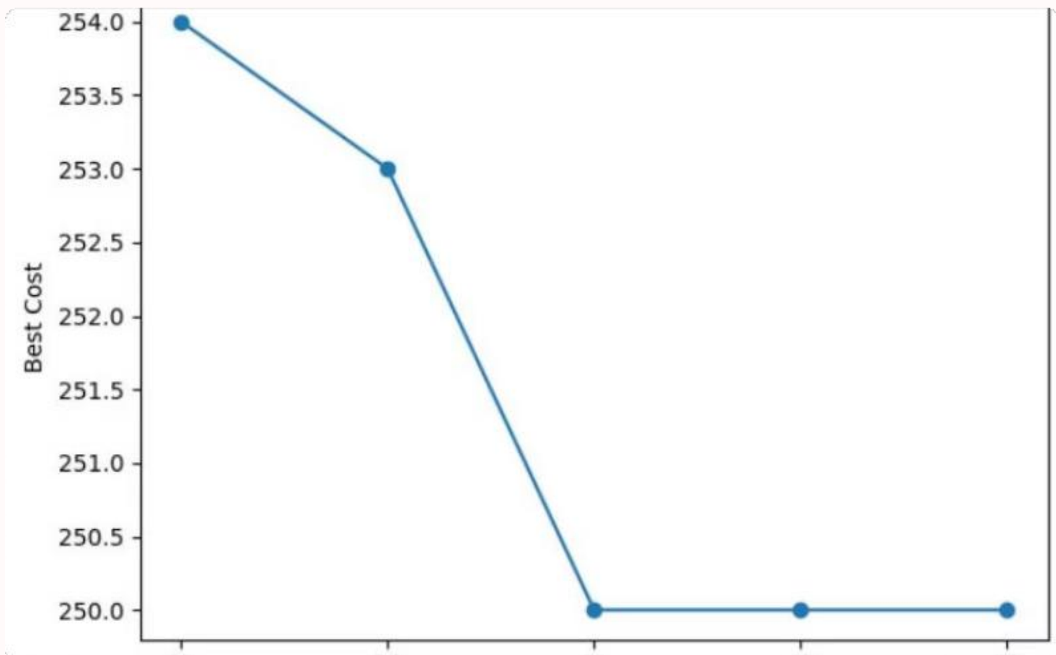


This plot shows that the best cost found by the ant stayed at 256 for all iterations. The solution was found early and did not improve further.

20 Cities, 1 Ant

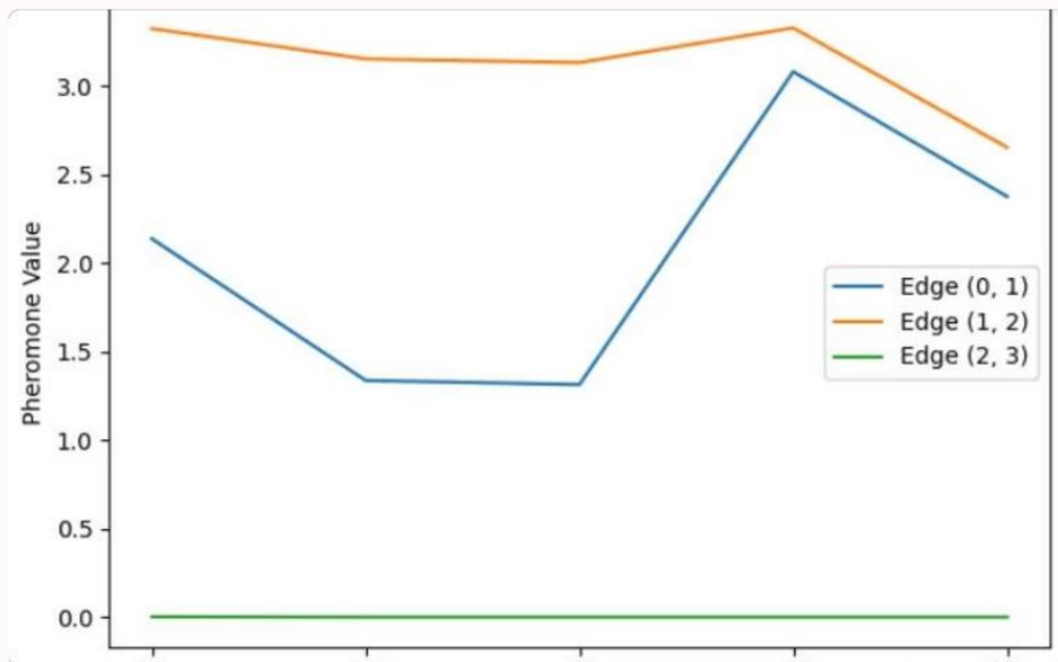


The pheromone values for edges (0, 1) and (1, 2) stayed moderate and increased slightly, showing these edges were used in good solutions. Edge (2, 3) was not used. 20 Cities, 1 Ant



The best cost improved over time, dropping from 254 to 250 by an iteration of 30, and then stayed the same. This shows the algorithm found a better solution as it progressed.

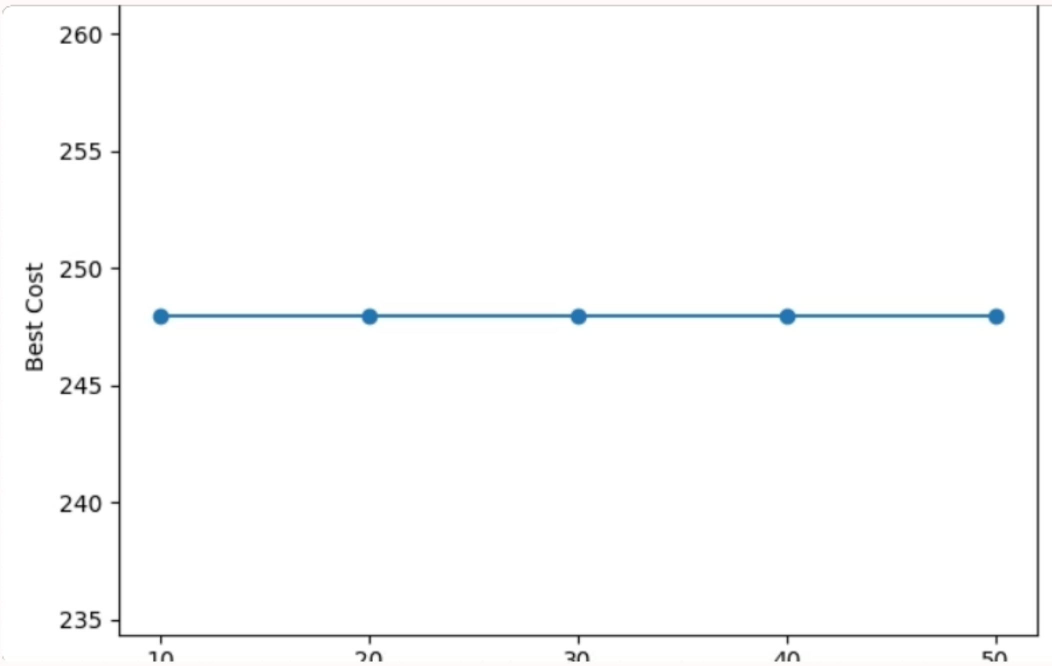
20 Cities, 5 Ant



The pheromone values for edges (0, 1) and (1, 2) fluctuated but stayed high, showing these edges were often used in good solutions. Edge (2, 3) was not used.

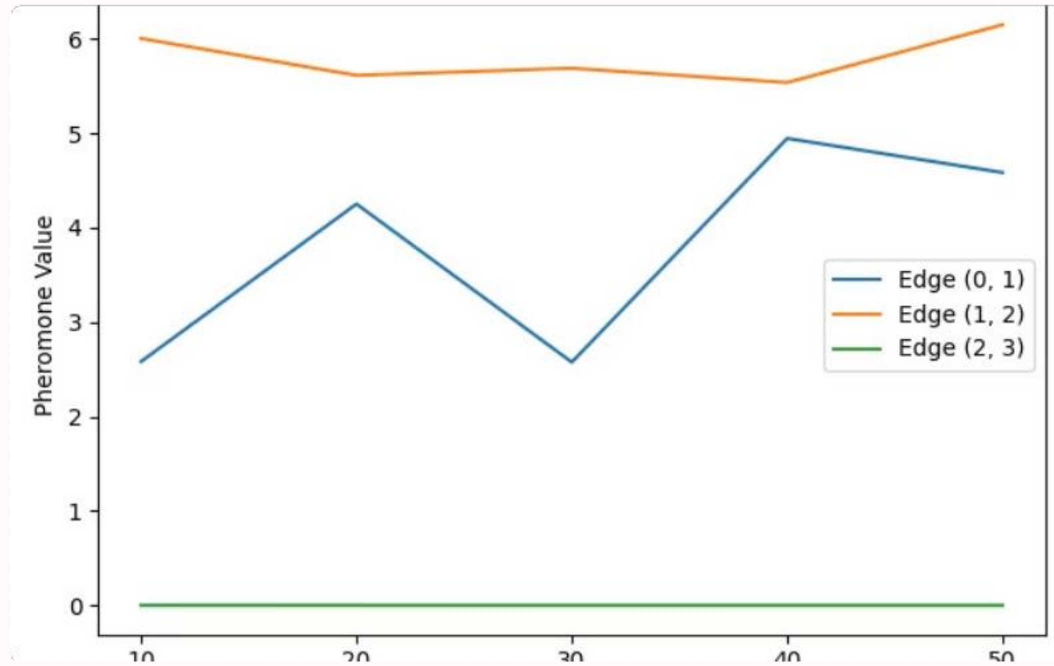
20 Cities, 5 Ant

20 Cities: Pheromone and Cost Trends



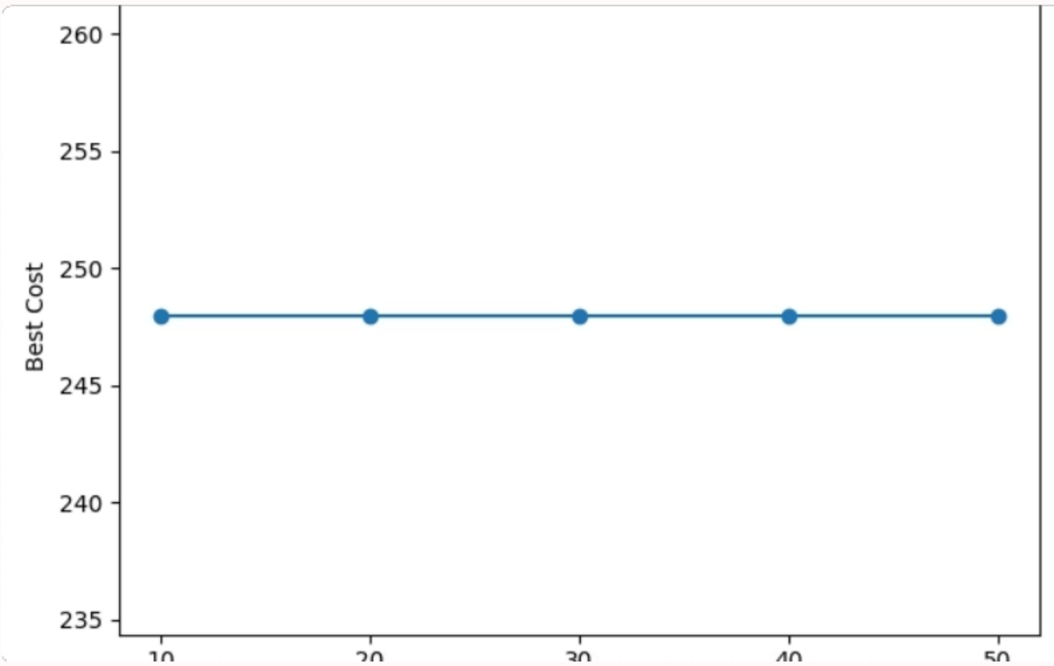
This plot shows that the best cost found by the ant stayed at 248 for all iterations. The solution was found early and did not improve any further.

20 Cities, 10 Ant



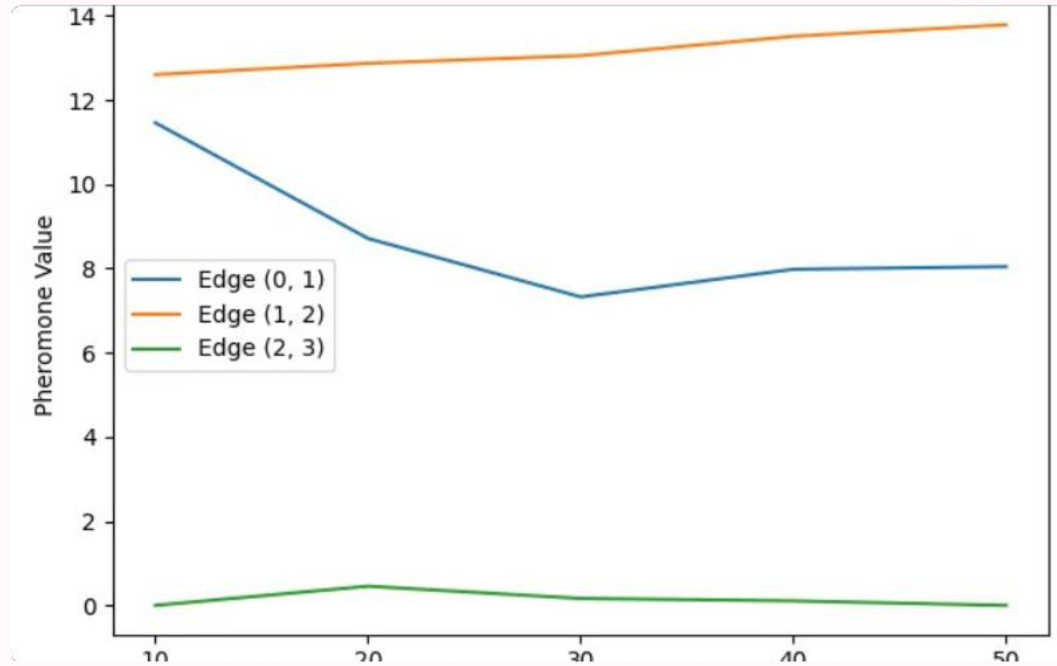
The pheromone values for edges (0, 1) and (1, 2) stayed high and varied, showing these edges were frequently used in good solutions. Edge (2, 3) was not used.

20 Cities, 10 Ant



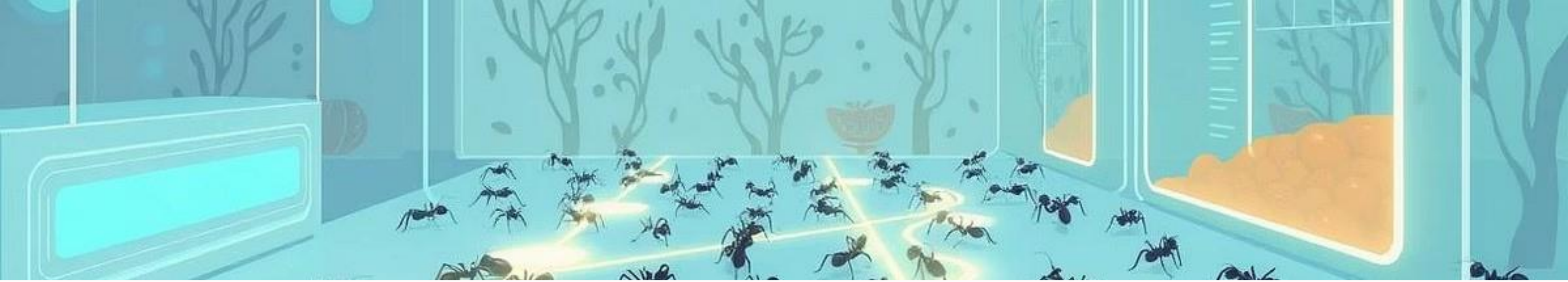
This plot shows that the best cost found by the ant stayed at 248 for all iterations. The solution was found early and did not improve any further.

20 Cities, 20 Ant



The pheromone values for edges (0, 1) and (1, 2) stayed high and increased, showing these edges were consistently used in the best solutions. Edge (2, 3) had low values, meaning it was rarely used.

20 Cities, 20 Ant



Analysis of Algorithm Behavior

Best cost stabilizes early, indicating quick solution discovery.

Pheromone values highlight edges used in good solutions.

Larger city sets and more ants cause more exploration before convergence.

Conclusion

ACO effectively solves TSP, especially with moderate ant numbers.

Pheromone reinforcement guides optimal path discovery.

More ants help larger problems but don't always improve best cost.