# Predator-Prey Simulation

## using Lotka-Volterra Model in Parallel

*Report generated on 2025-05-12 21:57:59*

# Predator-Prey Simulation using Lotka-Volterra Model in Parallel

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# Simulation Report

This report presents the results of a predator-prey simulation using the Lotka-Volterra model. The simulation was executed using parallel processing to improve performance and provide a more realistic spatial representation of ecosystem dynamics.

## Simulation Parameters:

| Parameter | Value |
|---|---|
| Time Period | 2023 - 2039 (16 years) |
| Grid Size | 5x5 (25 cells) |
| Initial Rabbits | 100 |
| Initial Wolves | 20 |

## Model Parameters:

| Parameter | Value |
|---|---|
| Alpha (rabbit growth rate) | 0.1 |
| Beta (predation rate) | 0.01 |
| Gamma (wolf death rate) | 0.05 |
| Delta (wolf reproduction rate) | 0.001 |

## Performance Metrics:

| Metric | Value |
|---|---|
| Total Execution Time | 24.00 seconds |
| CPU Cores Used | 8 |
| Average Time Per Year | 1.5003 seconds |
| Parallel Efficiency | Using 8 cores for 25 grid cells |

## Population Results:

| Metric | Rabbits | Wolves |
|---|---|---|
| Initial Population | 100 | 20 |
| Final Population | 448 | 10 |
| Maximum | 448 | 20 |

| Minimum | 100 | 10 |
|---|---|---|
| Average | 233.41 | 14.00 |

## Population by Year:

| Year | Rabbits | Wolves | Wolves/Rabbits |
|---|---|---|---|
| 2023 | 100 | 20 | 0.2000 |
| 2024 | 109 | 19 | 0.1743 |
| 2025 | 120 | 18 | 0.1500 |
| 2026 | 131 | 17 | 0.1298 |
| 2027 | 144 | 16 | 0.1111 |
| 2028 | 158 | 15 | 0.0949 |
| 2029 | 174 | 15 | 0.0862 |
| 2030 | 191 | 14 | 0.0733 |
| 2031 | 210 | 14 | 0.0667 |
| 2032 | 230 | 13 | 0.0565 |
| 2033 | 253 | 12 | 0.0474 |
| 2034 | 279 | 12 | 0.0430 |
| 2035 | 306 | 11 | 0.0359 |
| 2036 | 337 | 11 | 0.0326 |
| 2037 | 370 | 11 | 0.0297 |
| 2038 | 408 | 10 | 0.0245 |
| 2039 | 448 | 10 | 0.0223 |

## AI Analysis Summary:

AI summary could not be generated due to missing API key.
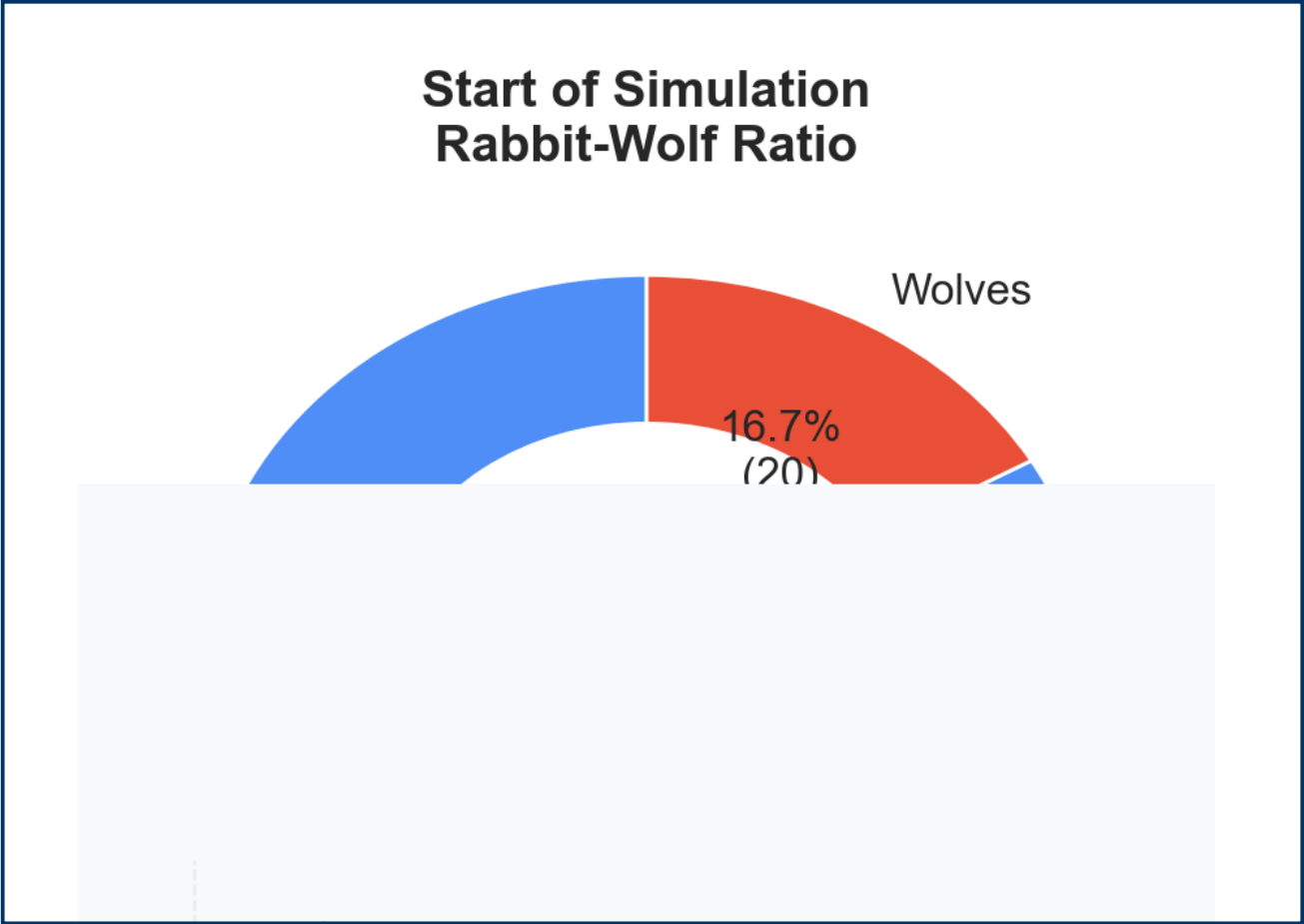
## Population Dynamics Over Time



*Figure 1: Population proportions of rabbits and wolves*

This donut chart displays the current population proportions of rabbits (prey) and wolves (predators). Rabbits make up a significantly larger portion of the ecosystem, which is typical in predator-prey relationships where prey populations must outnumber predators to sustain balance.

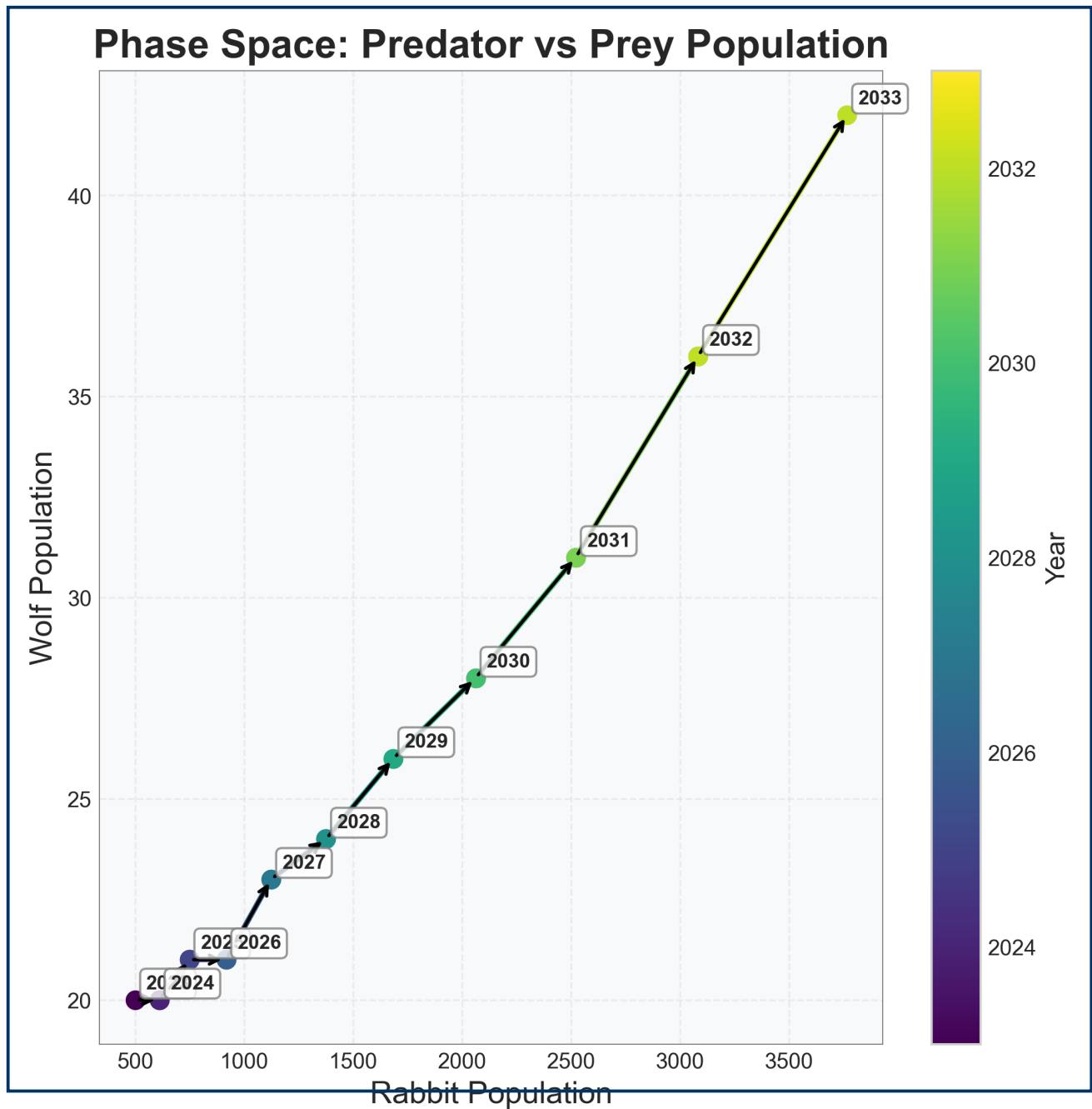## Phase Space: Predator vs Prey Population



*Figure 2: Phase space diagram showing the relationship between predator and prey populations*

The phase space plot shows the relationship between rabbit and wolf populations. Each point represents the population state at a specific time, and the arrows indicate the direction of change. The counterclockwise cycles are characteristic of predator-prey systems, showing how the populations influence each other over time.

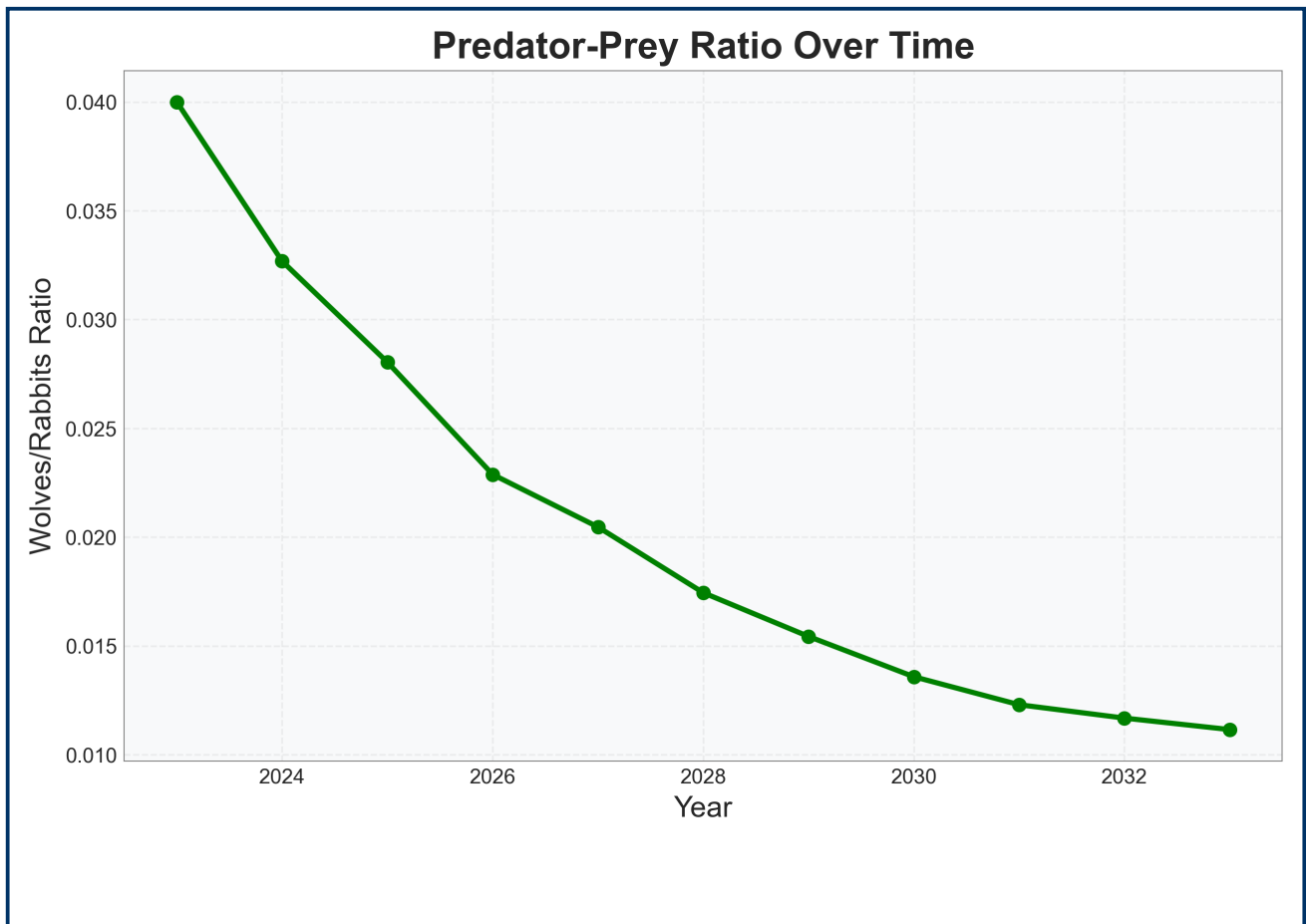## Predator-Prey Ratio Over Time



*Figure 3: Ratio of wolves to rabbits over time*

This graph shows the ratio of wolves to rabbits over time. The ratio fluctuates as the populations change, providing insight into the relative abundance of predators compared to prey. Higher ratios indicate more wolves per rabbit, which typically precedes a decline in the rabbit population.
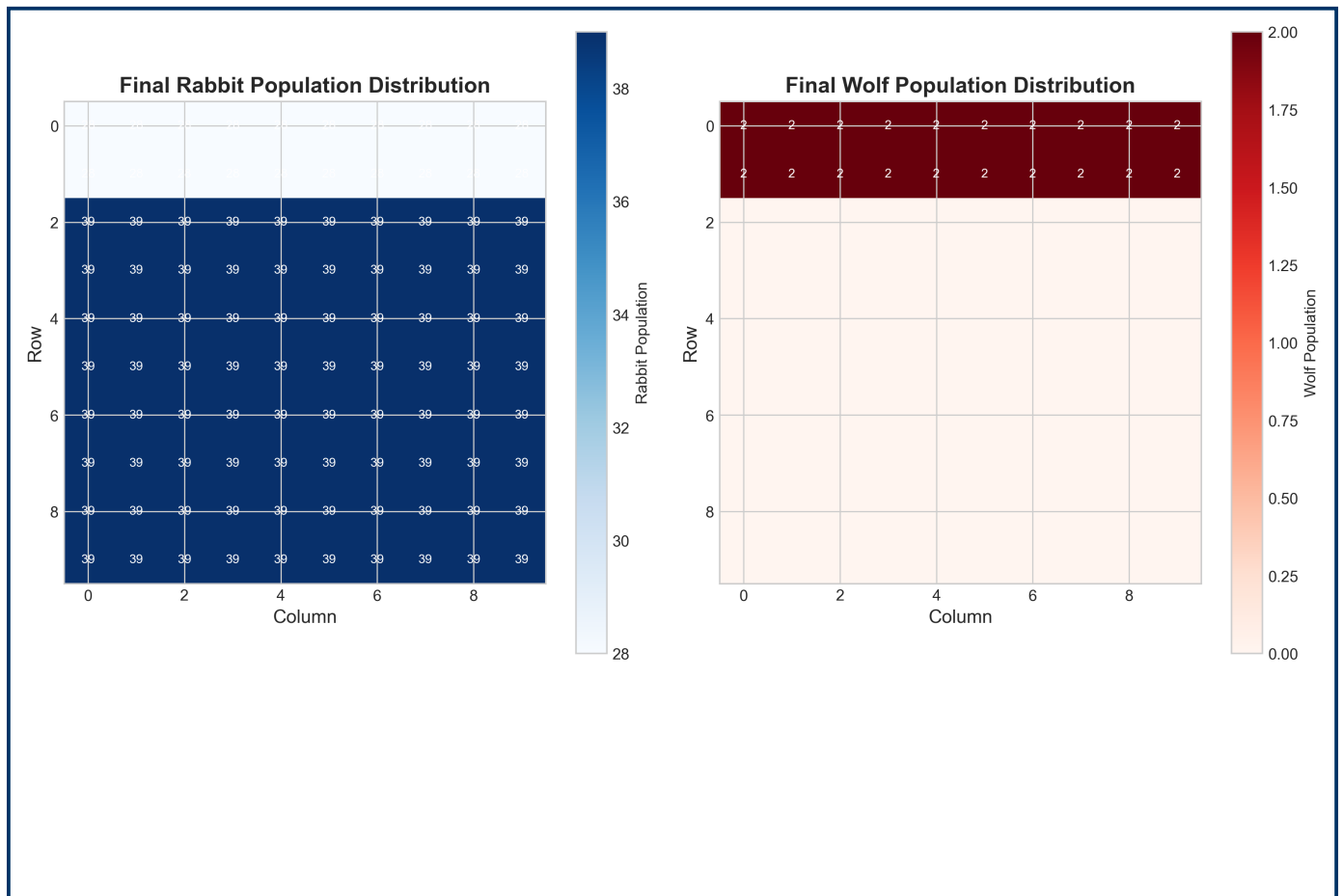
# Final Grid Population Distribution



*Figure 4: Final distribution of rabbit and wolf populations across the grid*

This visualization shows the final distribution of rabbit and wolf populations across the 5×5 grid. Each cell represents a distinct area in the ecosystem, with its own population dynamics. The parallel processing approach allowed each grid cell to be calculated independently, providing a more realistic spatial representation of the ecosystem.

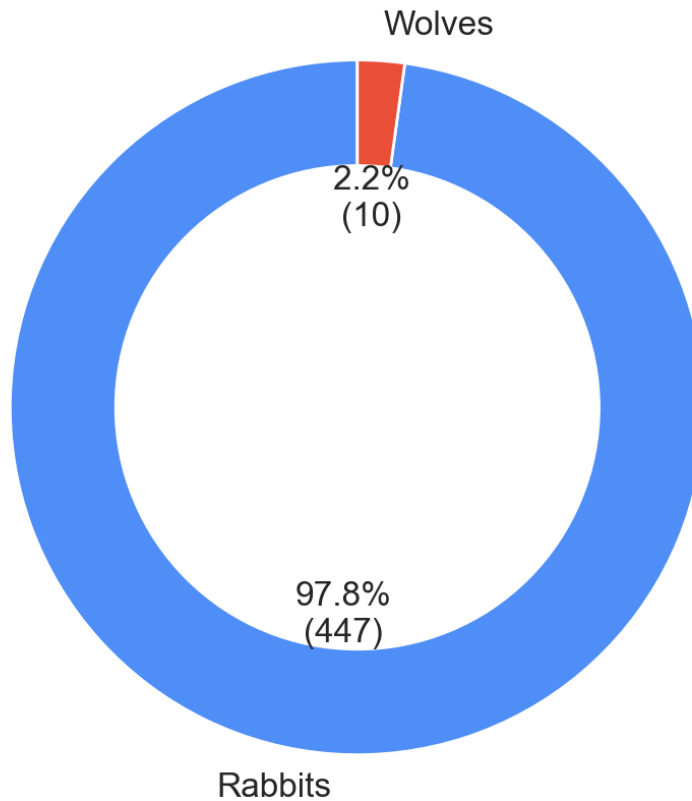## Rabbit-Wolf Ratio at Start of Simulation

*Figure: Rabbit-Wolf Ratio at Start of Simulation*

This circular chart visualizes the proportion of rabbits and wolves, providing an intuitive overview of the predator-prey ratio.

## Rabbit-Wolf Ratio at End of Simulation



*Figure: Rabbit-Wolf Ratio at End of Simulation*

This circular chart visualizes the proportion of rabbits and wolves, providing an intuitive overview of the predator-prey ratio.
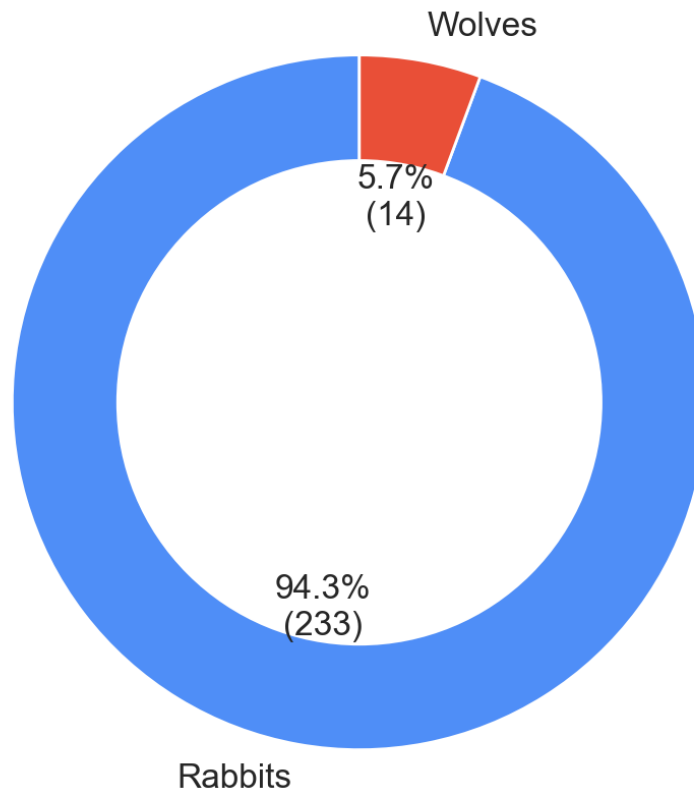
## Average Rabbit-Wolf Ratio Over Simulation



*Figure: Average Rabbit-Wolf Ratio Over Simulation*

This circular chart visualizes the proportion of rabbits and wolves, providing an intuitive overview of the predator-prey ratio.

## Conclusion

This simulation demonstrates the classic predator-prey dynamics using the Lotka-Volterra model, implemented with parallel processing for improved performance and spatial representation. Starting with 100 rabbits and 20 wolves, the simulation tracked population changes over 17 years across a 5×5 grid.

Key findings:

1. The rabbit population exhibited cyclical behavior, reaching a maximum of 448 and a minimum of 100.

2. The wolf population followed a similar pattern with a phase shift, reaching a maximum of 20 and a minimum of 10.

3. The phase space plot revealed the characteristic counterclockwise cycles of predator-prey systems, demonstrating the lag between population changes.

4. The parallel processing approach utilizing 8 CPU cores allowed for efficient computation, completing the simulation in 24.00 seconds.

The results align with theoretical expectations for predator-prey systems, showing the oscillatory behavior and phase relationships between populations. The parallel implementation not only improved performance but also provided a more realistic spatial representation of ecosystem dynamics.