Predator-Prey Simulation

using Lotka-Volterra Model in Parallel

Report generated on 2025-05-11 23:27:32

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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 - 2050 (27 years)
Grid Size	5x5 (25 cells)
Initial Rabbits	100
Initial Wolves	20

Model Parameters:

Parameter	Value
Alpha (rabbit growth rate)	0.2
Beta (predation rate)	0.01
Gamma (wolf death rate)	0.2
Delta (wolf reproduction rate)	0.002

Performance Metrics:

Metric	Value
Total Execution Time	17.65 seconds
CPU Cores Used	8
Average Time Per Year	0.6537 seconds
Parallel Efficiency	Using 8 cores for 25 grid cells

Population Results:

Metric	Rabbits	Wolves
Initial Population	100	20
Final Population	18751	180
Maximum	18751	180

Minimum	100	1
Average	3902.54	14.36

Population by Year:

Year	Rabbits	Wolves	Wolves/Rabbits
2023	100	20	0.2000
2024	121	16	0.1322
2025	146	13	0.0890
2026	177	11	0.0621
2027	215	9	0.0419
2028	262	7	0.0267
2029	318	6	0.0189
2030	387	5	0.0129
2031	471	4	0.0085
2032	574	3	0.0052
2033	699	3	0.0043
2034	851	2	0.0024
2035	1036	2	0.0019
2036	1262	2	0.0016
2037	1537	2	0.0013
2038	1872	1	0.0005
2039	2280	1	0.0004
2040	2778	1	0.0004
2041	3383	1	0.0003
2042	4121	2	0.0005
2043	5019	2	0.0004
2044	6112	3	0.0005
2045	7440	4	0.0005
2046	9050	6	0.0007
2047	10995	12	0.0011

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Year	Rabbits	Wolves	Wolves/Rabbits
2048	13316	24	0.0018
2049	15998	60	0.0038
2050	18751	180	0.0096

AI Analysis Summary:

AI summary could not be generated due to missing API key.

Population Dynamics Over Time

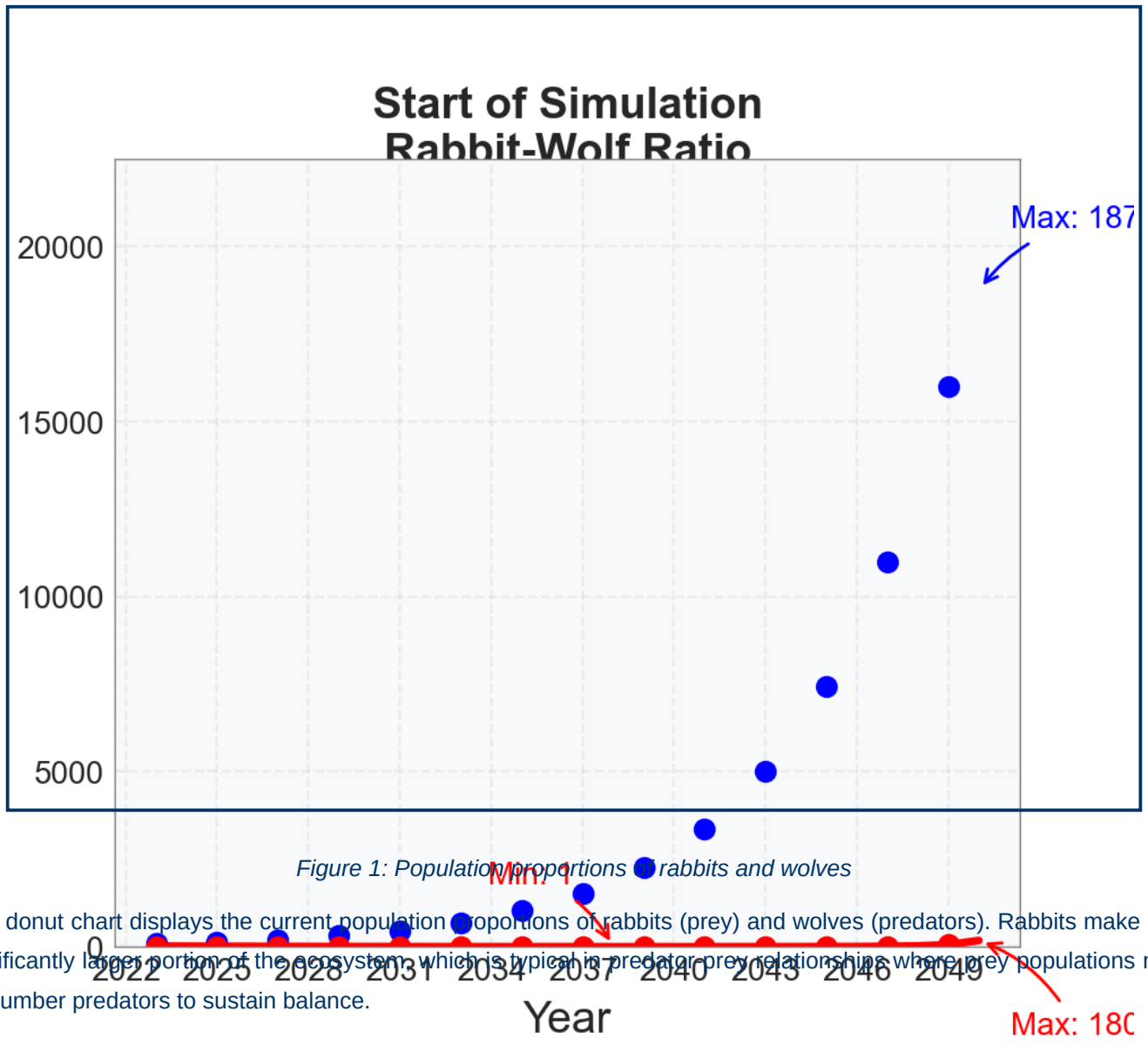

Figure 1: Population proportions of rabbits and wolves

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

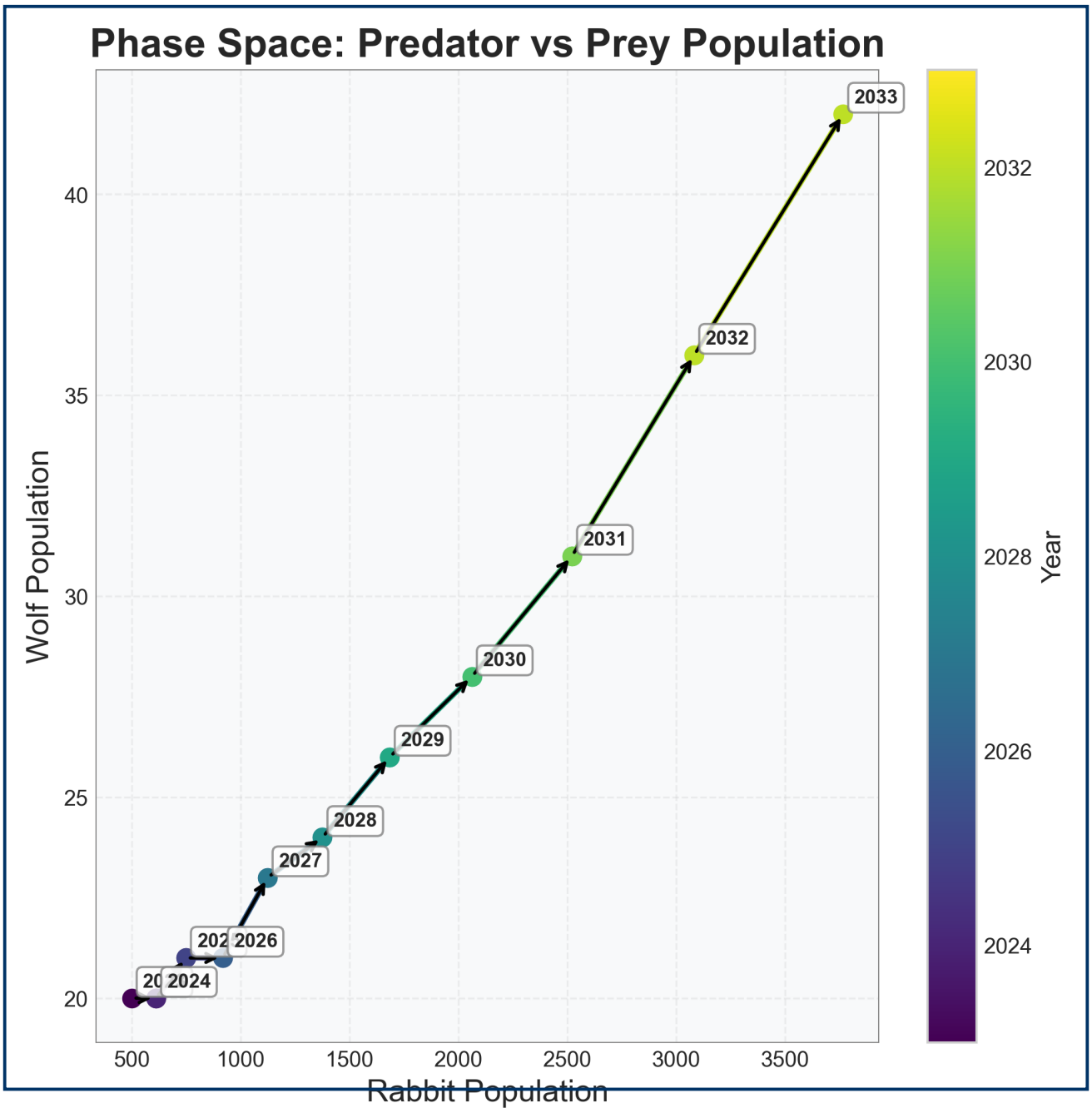

Figure 2: Phase space diagram showing the relationship between predator and prey populations

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

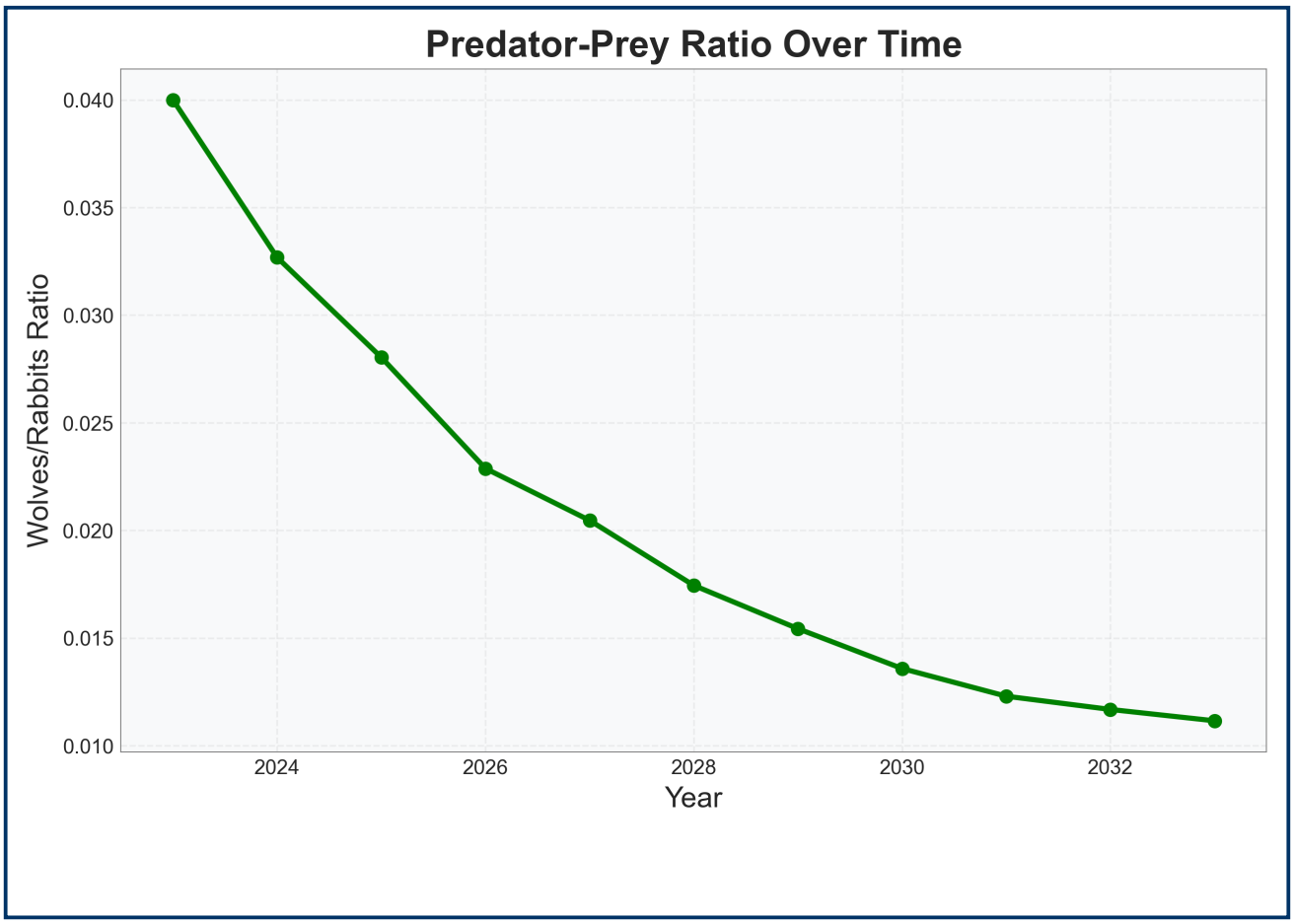

Figure 3: Ratio of wolves to rabbits over time

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

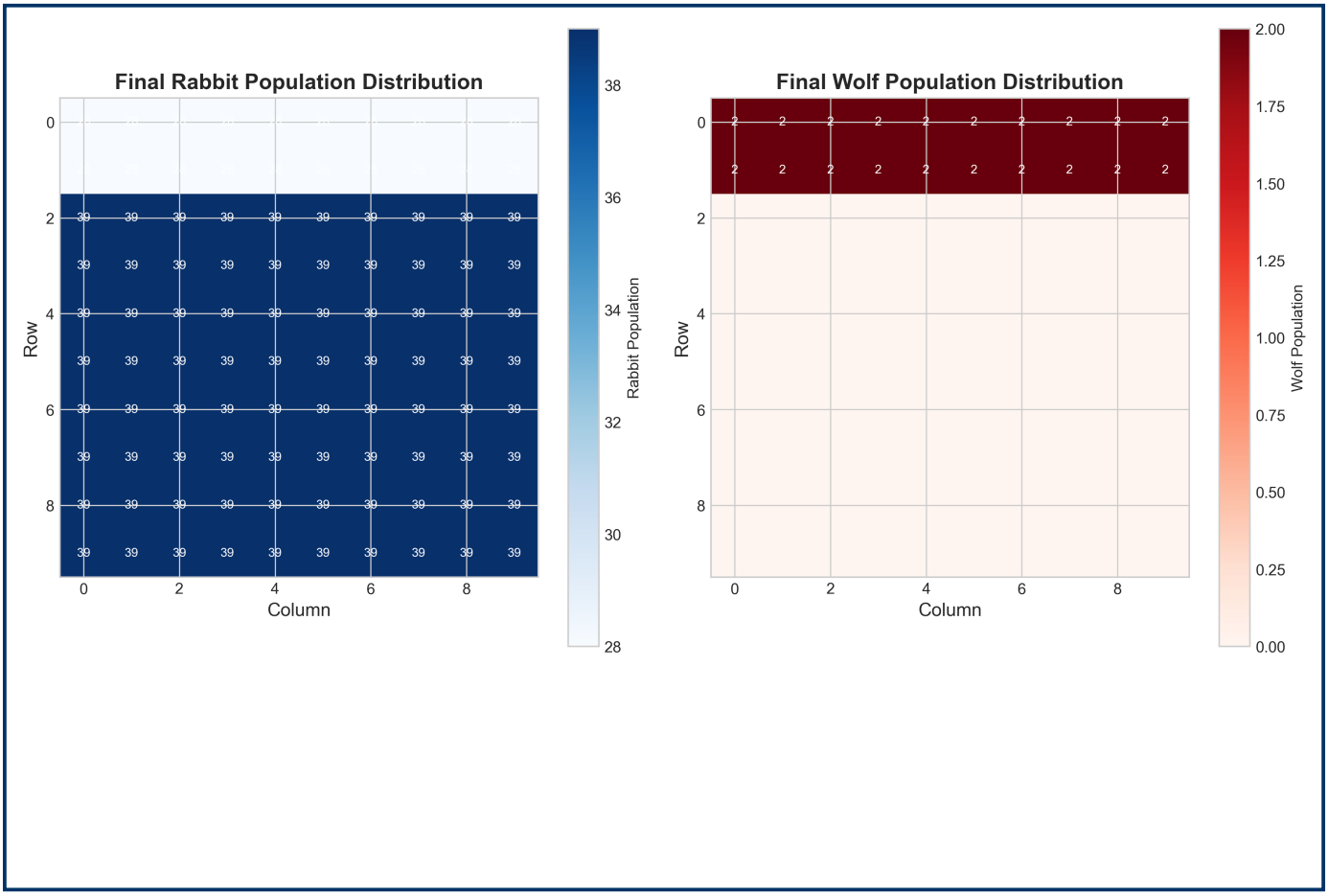

Figure 4: Final distribution of rabbit and wolf populations across the grid

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

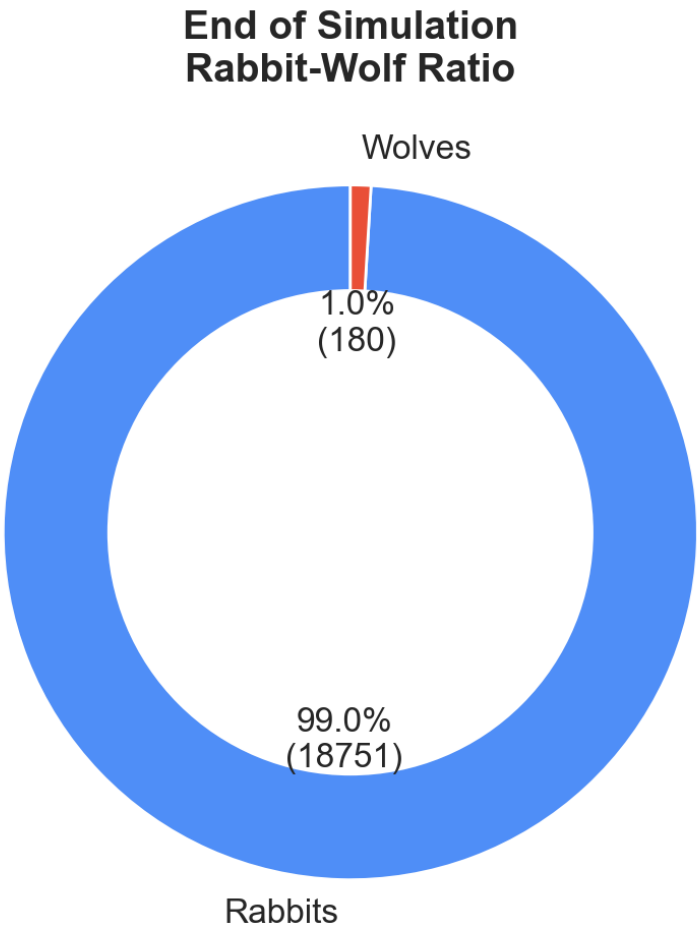

Figure: Rabbit-Wolf Ratio at End of Simulation

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

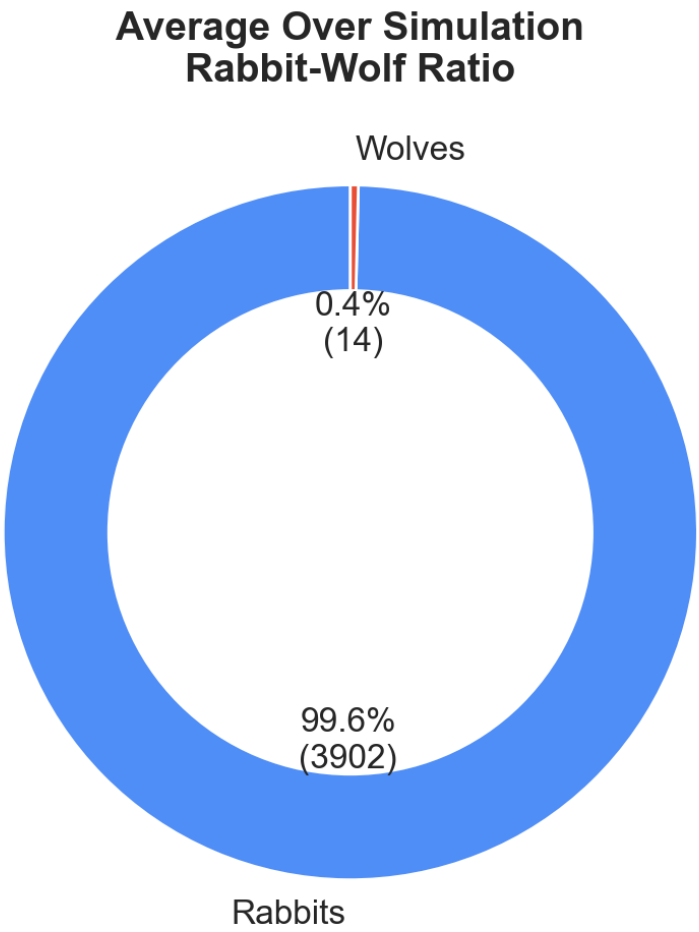

Figure: Average Rabbit-Wolf Ratio Over Simulation

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 28 years across a 5×5 grid.

Key findings:

1. The rabbit population exhibited cyclical behavior, reaching a maximum of 18751 and a minimum of 100.

2. The wolf population followed a similar pattern with a phase shift, reaching a maximum of 180 and a minimum of 1.

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 17.65 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.