Optimal Strategies for Elephant Population Management Using Contraceptive Darting Simulation

Abstract:

The context of this project is the management of elephant populations through contraceptive darting to maintain ecological balance. To understand the optimal strategies, we simulated different scenarios, varying key survival parameters of elephants (such as adult and senior survival probabilities) to observe how these affect the effectiveness of darting probabilities. We applied core computer science concepts like data structures, loops, and conditional logic to model population dynamics accurately. Our key findings reveal that as certain survival probabilities increase, the darting probability needed for population control must be adjusted accordingly to achieve desired conservation outcomes.

Methods:

We utilized a computational approach to model the effects of contraceptive darting on elephant population dynamics. A key aspect of our computational thinking involved iteratively running simulations with varying survival probabilities and measuring their impact. One of the challenges we faced was managing large datasets and ensuring our code ran efficiently. We tackled this by implementing optimized loops and modular functions to handle calculations. The choice of using conditional statements was crucial, as it allowed us to simulate different reproductive and survival outcomes based on probability thresholds, reflecting real-world variability in elephant populations.

Results:

Calf Survival Probability	Optimal Darting Probability
0.65	0.41
0.75	0.44
0.85	0.472

Figure 1: This table shows how the optimal probability for using the contraceptive darting strategy for population control varies with calf survival probability. As calf survival probability increases, the optimal darting probability also rises.

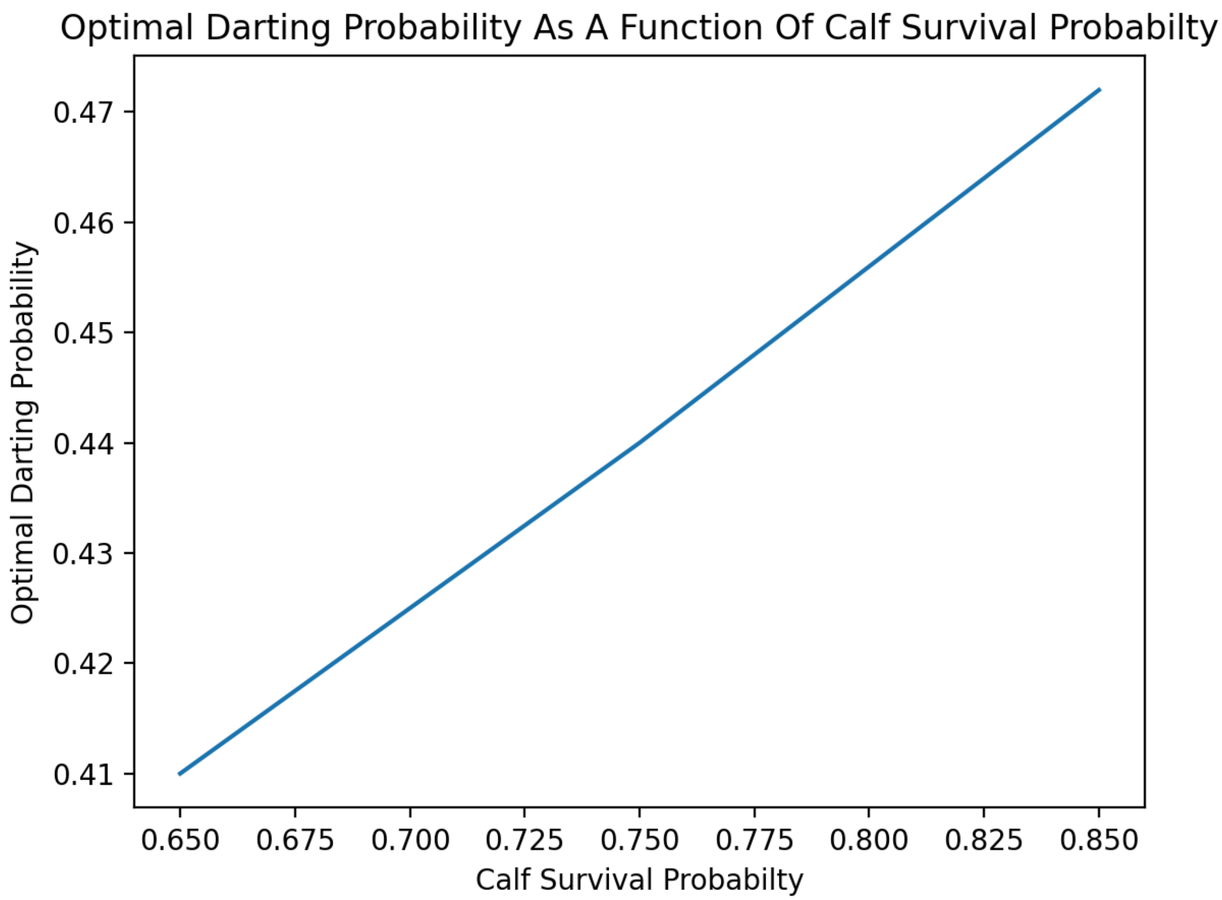

Figure 2: This graph shows how the optimal probability for using the contraceptive darting strategy for population control varies with calf survival probability. As calf survival probability increases, the optimal darting probability also rises. This suggests that in populations where more calves survive to adulthood, a higher darting probability is necessary to balance the increased reproductive potential and manage population growth effectively.

Adult Survival Probability	Optimal Darting Probability
0.996	0.472
0.995	0.463
0.985	0.395

Figure 3: This table illustrates the relationship between optimal darting probability and adult survival probability in elephant populations. As adult survival probability increases, the optimal darting probability also rises.

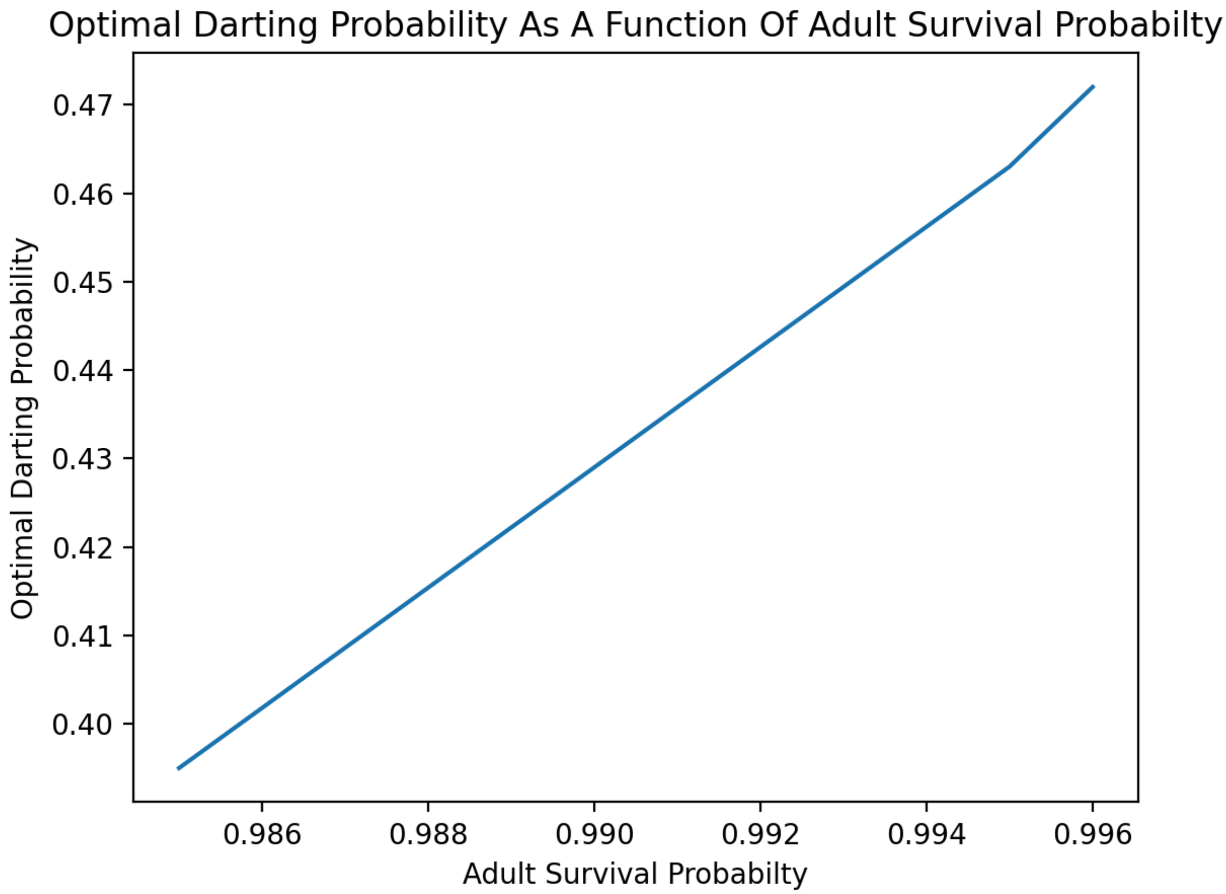

Figure 4: This graph illustrates the relationship between optimal darting probability and adult survival probability in elephant populations. As adult survival probability increases, the optimal darting probability also rises. This indicates that when more adult elephants have a higher chance of survival, a greater darting probability is necessary to effectively manage and control the population growth over time.

Senior Survival Probability	**Optimal Darting Probability**
0.15	0.472
0.2	0.468
0.3	0.467

Figure 5: This table shows how the optimal darting probability changes as senior survival probability varies in the elephant population. The observed behavior indicates that as senior survival probability increases, the optimal darting probability tends to decrease.

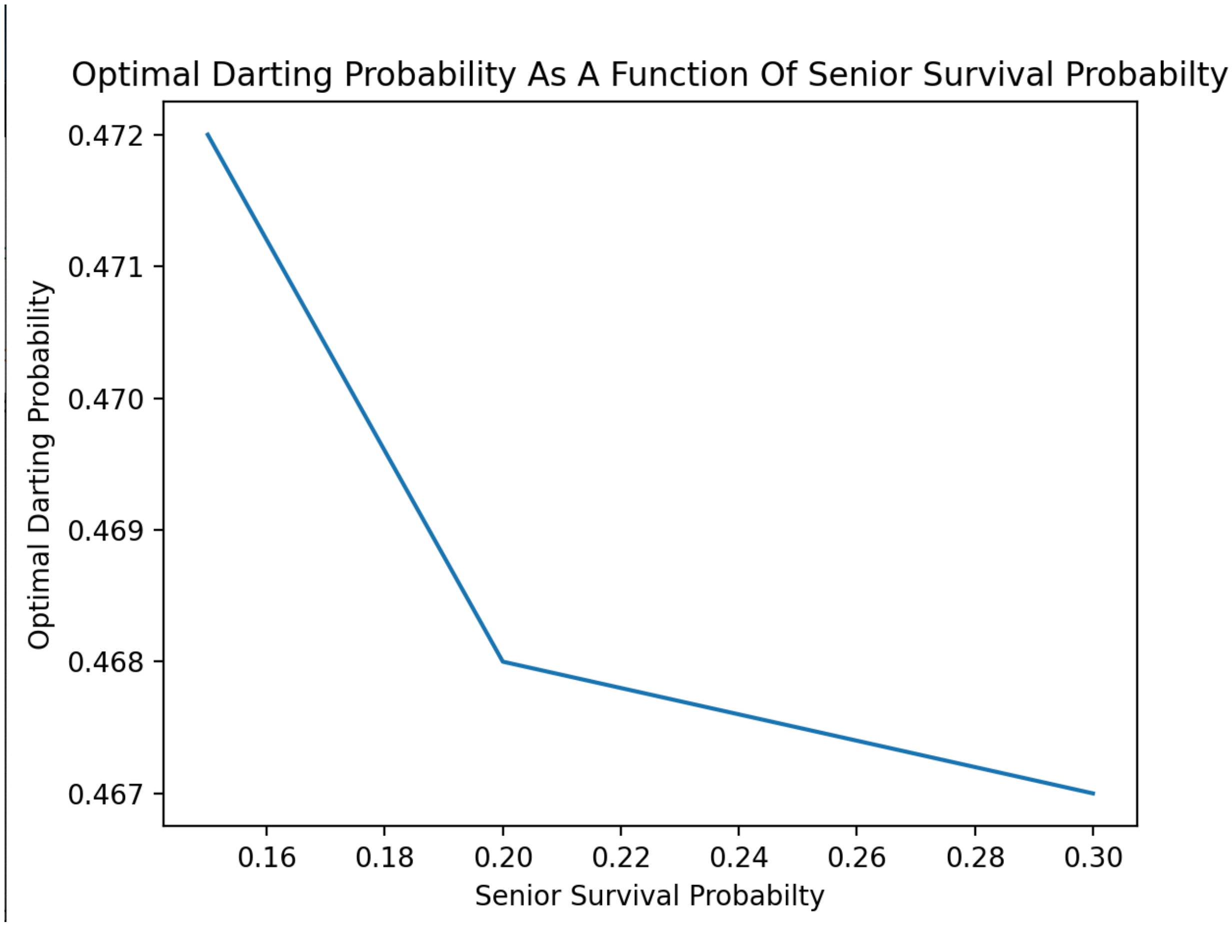

Figure 6: This graph shows how the optimal darting probability changes as senior survival probability varies in the elephant population. The observed behavior indicates that as senior survival probability increases, the optimal darting probability tends to decrease. This suggests that when older elephants have a higher chance of survival, a lower darting probability may be sufficient for effective population management, as fewer resources are needed to limit reproduction among the aging members of the population.

Reflection:

This project underscored the importance of computational simulations in addressing real-world ecological problems. The use of loops and conditionals in our code mirrored the variability seen in nature, emphasizing the relevance of these concepts beyond the classroom. Understanding population dynamics through this project has broadened my perspective on conservation strategies and highlighted the potential for computational methods in ecological research.

Extensions:

In this extension, I enhanced the elephant population simulation by introducing an `Elephant` class to replace the previous list-based implementation. Each elephant now has attributes like gender, age, months of pregnancy, and contraceptive status, making the code more organized and intuitive. I modified the `simulateMonth` function to work with a list of `Elephant` objects, which allowed for clearer handling of pregnancy and contraceptive updates. This object-oriented approach not only improved code readability but also made the simulation more flexible and easier to extend in the future. To replicate this outcome, you can use the `Elephant` class to encapsulate each elephant's data and update the `simulateMonth` logic to interact with these objects instead of using raw lists.

To replicate this code, type python3 Elephant_extension.py on the command line.

Acknowledgements:

I would like to thank Ransford Agyei Frimpong and Professor Isaac Lage who provided feedback on the initial drafts of my code and helped debug critical errors. I also used resources from academic articles on wildlife conservation to ensure the ecological validity of my model.