

DSUTM
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Mathematical Modeling of Hair-Plucking Birds

Problem A

Team number: 1054

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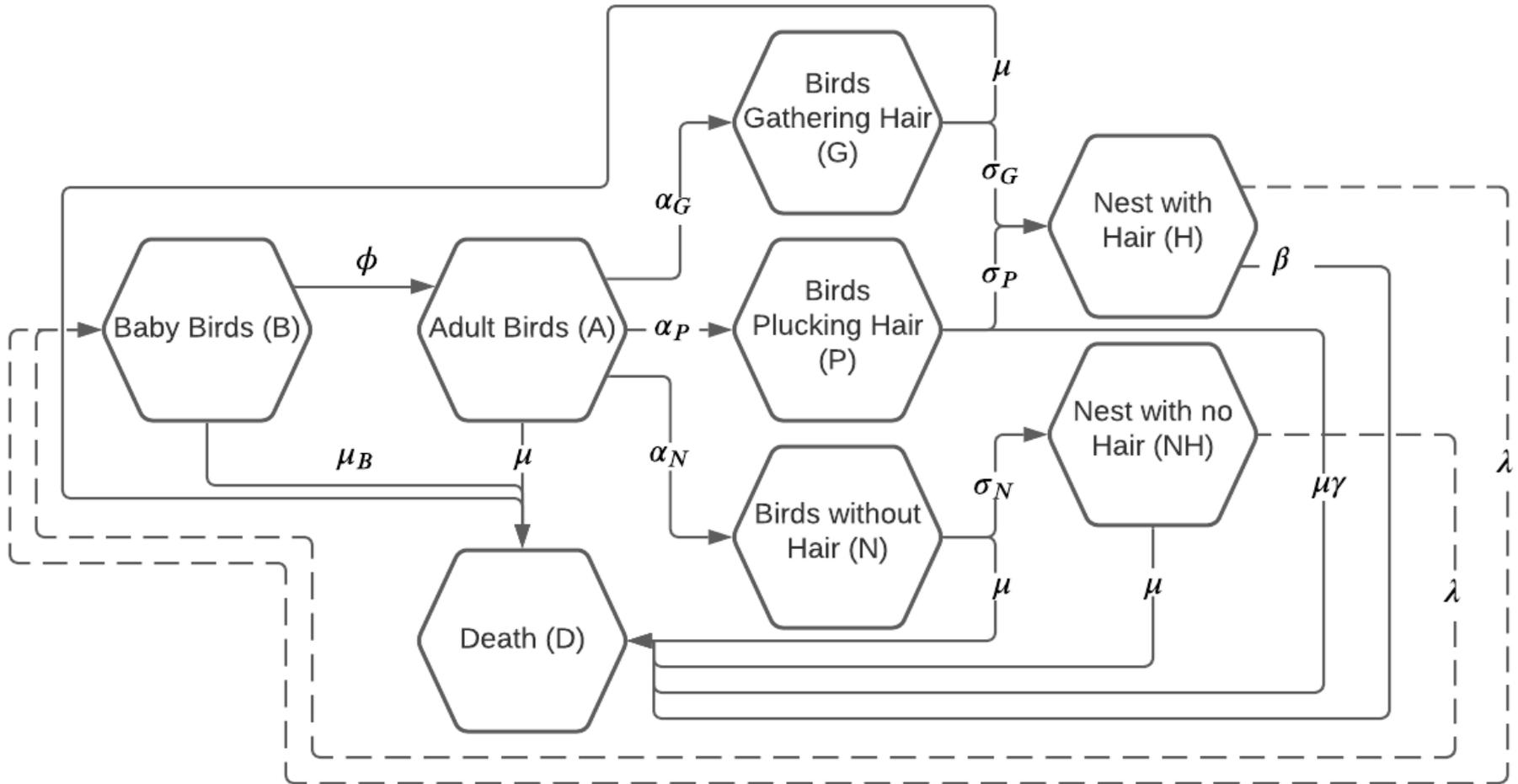
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Problem Restated

Birds in the genus *Paridae* have been observed snatching hair from live animals. Many birds of this genus have hair in their nest, but not all birds obtain this hair by pulling it off of live animals. This begs the following questions:

What are the benefits of having hair in the nest?
What are the benefits of freshly pulled hair over gathered hair?

Schematic Diagram



Parameters

Symbol	Purpose	
λ	Birth rate	2.76
μ	Death rate	$1/(365 \cdot .00243)$
α_G	The rate at which birds go to gathering compartment	.84
α_N	The rate at which birds go to gathering no hair in nest compartment	.14
α_P	The rate at which birds go to plucking compartment	.02
σ_G	Time it takes to build nest for birds gathering hair	14 days
σ_N	Time it takes to build nest for birds not using hair	7 days
σ_P	Time it takes to build nest for birds plucking hair	2 days
β	The added survival rate that the hair gives the birds	0.0241
γ	The added risk of dying that plucking causes the birds	1/11

Differential Equations

$$\frac{dB}{dt} = \lambda(H(t) + NH(t)) - \phi B(t) - \mu_b B(t)$$

$$\frac{dA}{dt} = \phi B(t) - \alpha_g A(t) - \alpha_p A(t) - \alpha_n A(t) - \mu A(t)$$

$$\frac{dG}{dt} = \alpha_g A(t) - \sigma_g G(t) - \mu G(t)$$

$$\frac{dP}{dt} = \alpha_p A(t) - \sigma_p P(t) - (\mu + \gamma)P(t)$$

$$\frac{dN}{dt} = \alpha_n A(t) - \sigma_n N(t) - \mu N(t)$$

$$\frac{dH}{dt} = \sigma_g G(t) + \sigma_p P(t) - \beta H(t)$$

$$\frac{dNH}{dt} = \sigma_n N(t) - \mu NH(t)$$

$$\frac{dD}{dt} = (\mu + \gamma)P(t) + \mu A(t) + \mu G(t) + \mu N(t) + \mu\beta H(t) + \mu NH(t) + \mu_b B(t)$$

Assumptions

1. For the bird population, half the population is female, and the other half is male.
2. 10/11 times the live animal is not bothered by the bird plucking. If a bird has a bad encounter (1/11 chance) with a live animal while plucking, then it dies.
3. Our dataset represents all the birds in the *Paridae* genus
4. 90% of baby birds do not make it to adulthood
5. The total population of birds is split evenly across the seven climates
6. If a bird has hair in the nest, but doesn't pluck it gathered the hair.

The Benefits

Benefits of Hair in Nest:

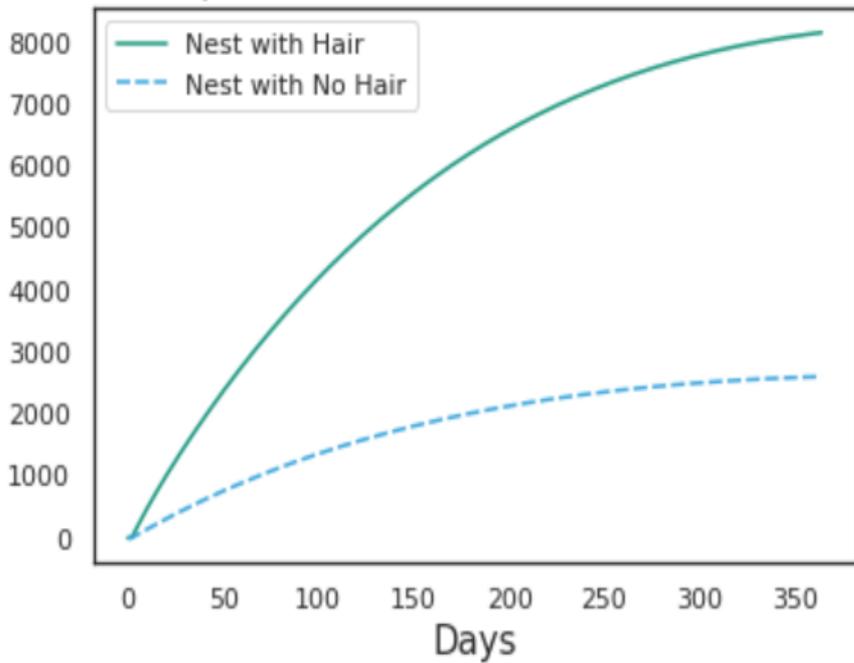
- Extra warmth and insulation
- Deter predators

Benefits of Plucking over Gathering:

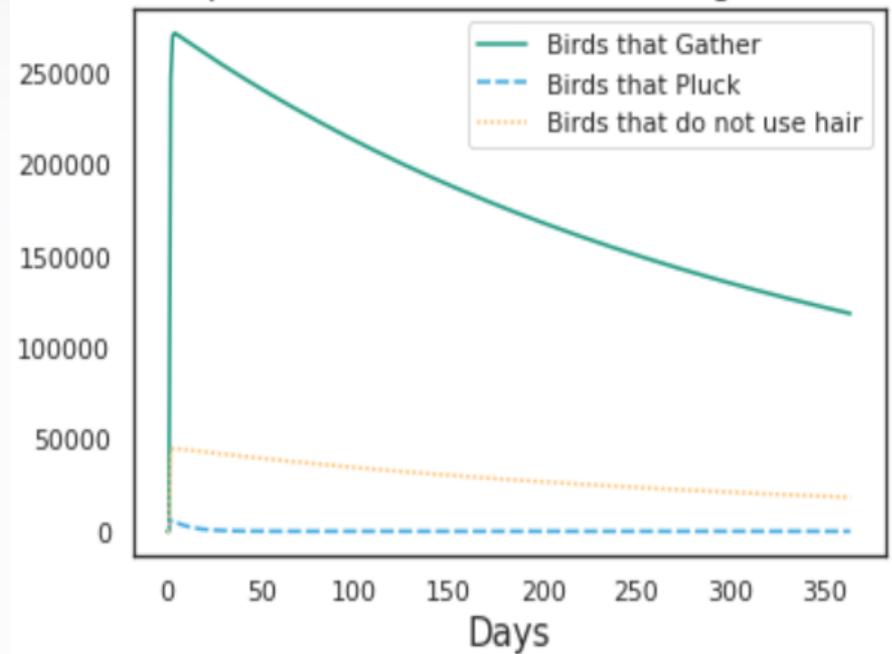
- Ward off predators with the fresh scent on plucked hair
- Lowers time spent building a nest

Population Without Considering Climate

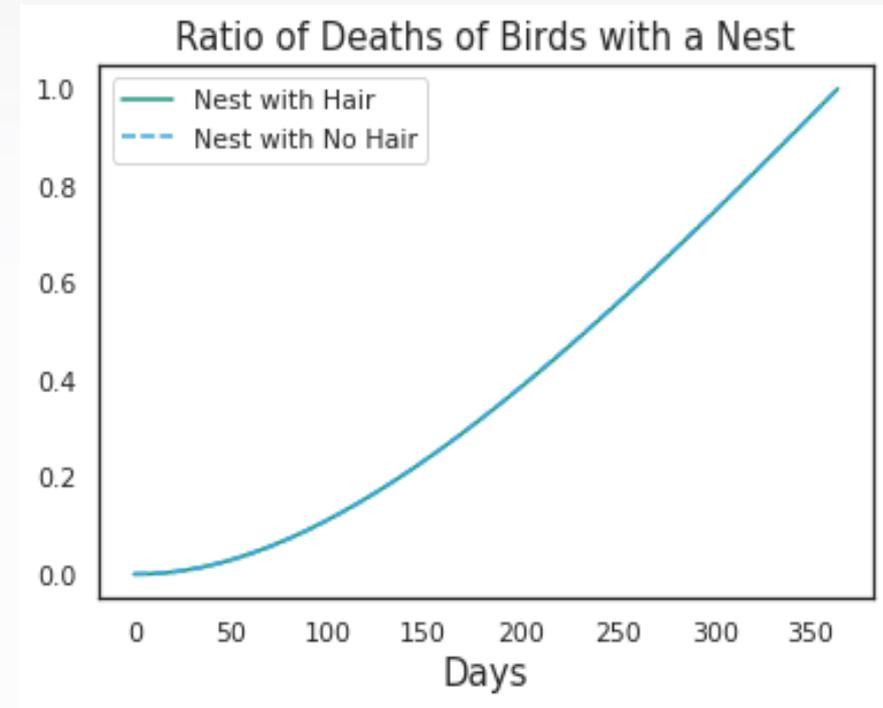
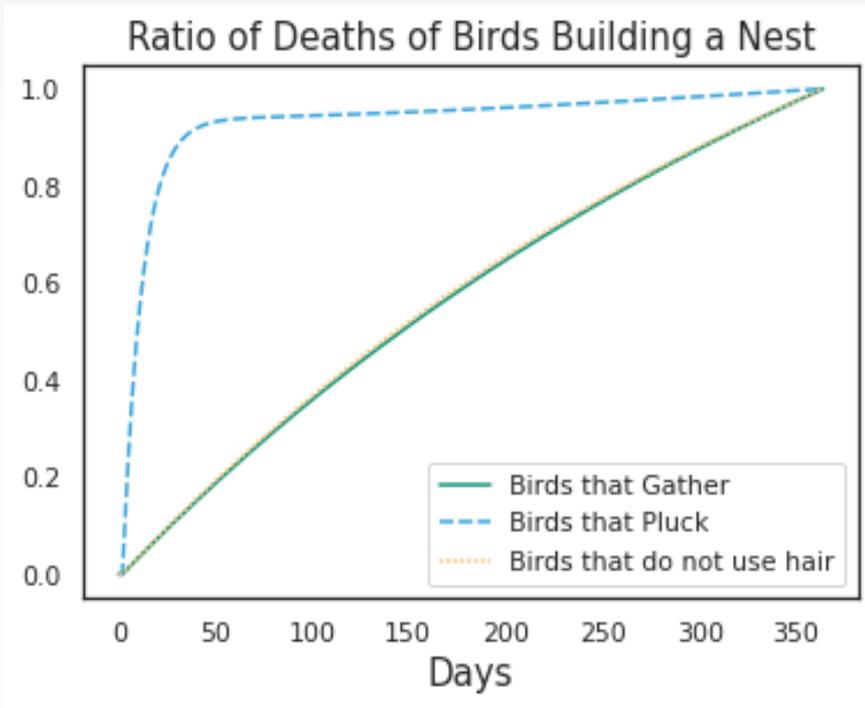
Population of Adult Birds with a Nest



Population of Adult Birds Building a Nest



Death Rates Without Considering Climate



Breakdown By Climate

Holarctic:

100% hair in nest
0% pluck hair

Nearctic:

100% hair in nest
0% pluck hair

Subtropical:

75% hair in nest
0% pluck hair

Subtropical Temperate:

100% hair in nest
20% pluck

Temperate:

91% hair in nest
0% pluck hair

Tropical:

57% hair in nest
0% pluck hair

Tropical Subtropical:

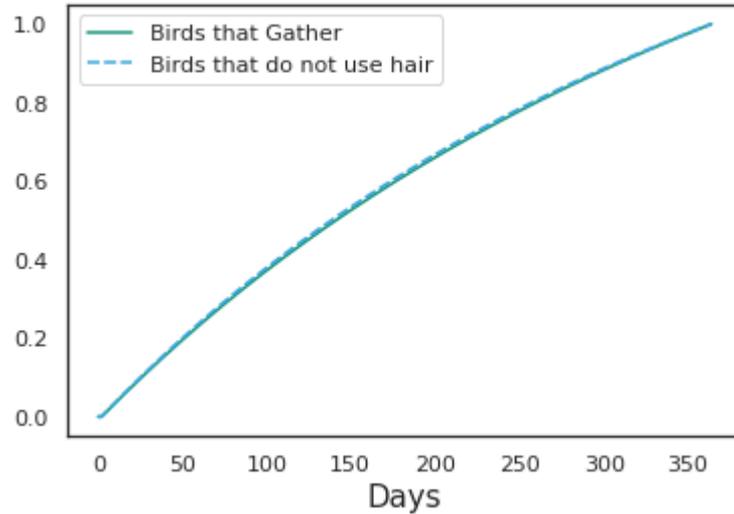
100% hair in nest
0% pluck hair

Total:

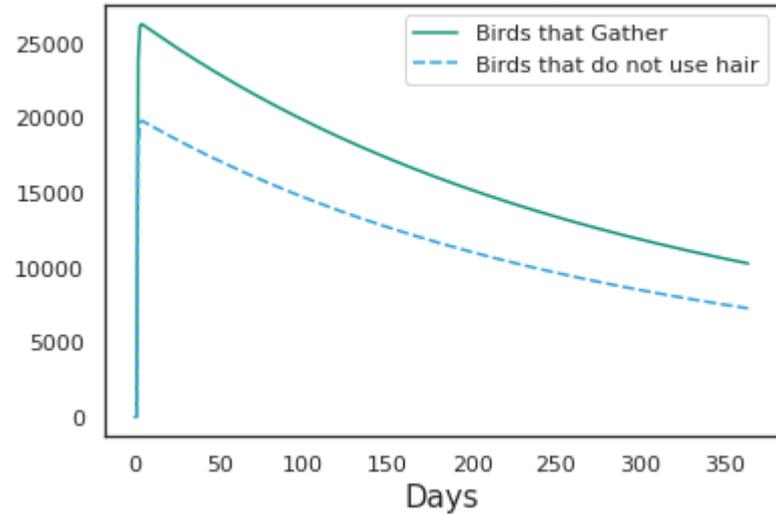
86% hair in nest
2% pluck hair

Results - Tropical Climate

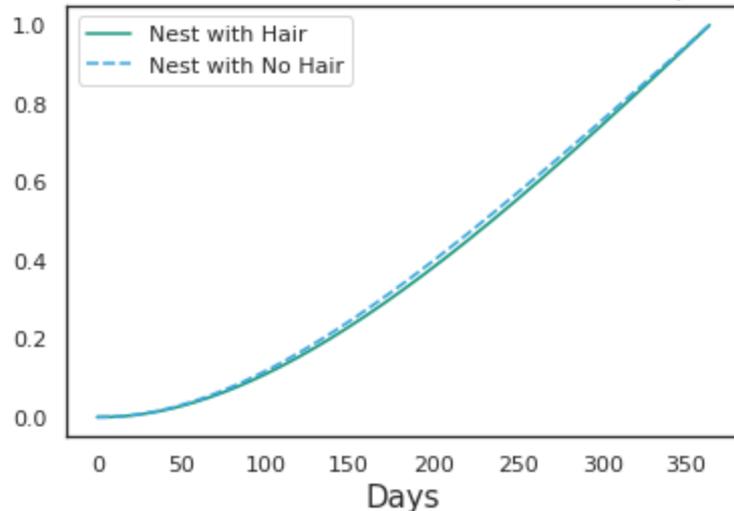
Ratio of Deaths of Birds Building a Nest - Tropical



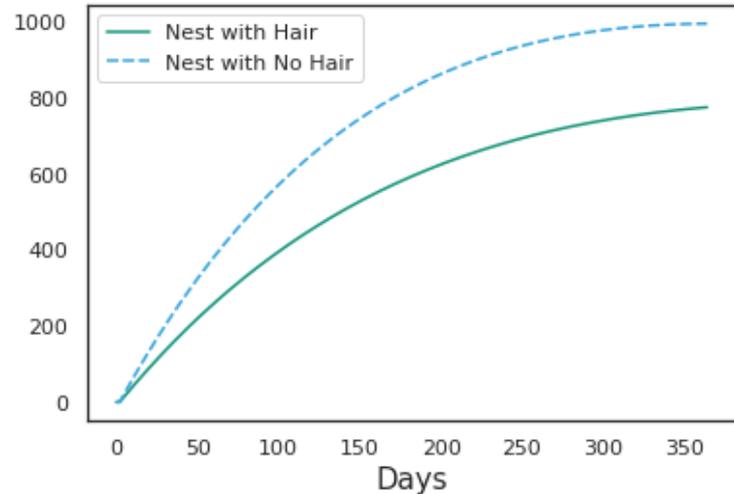
Population of Adult Birds Building a Nest - Tropical



Ratio of Deaths of Birds with a Nest - Tropical

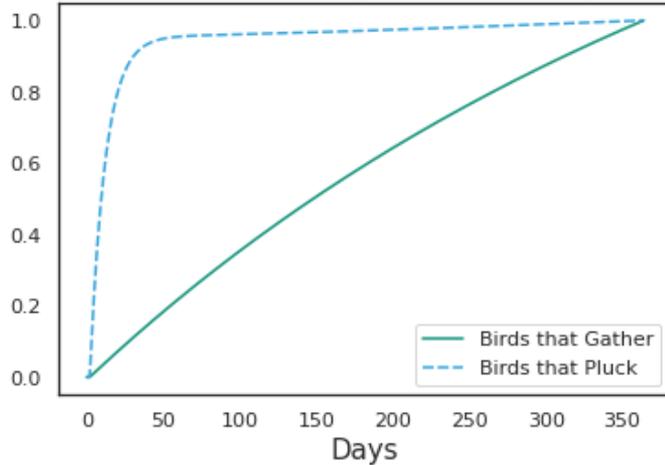


Population of Adult Birds with a Nest - Tropical

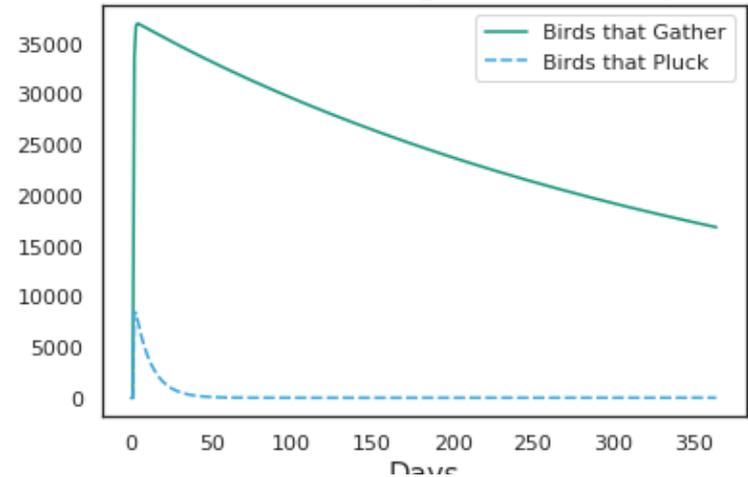


Results - Subtropical Climate

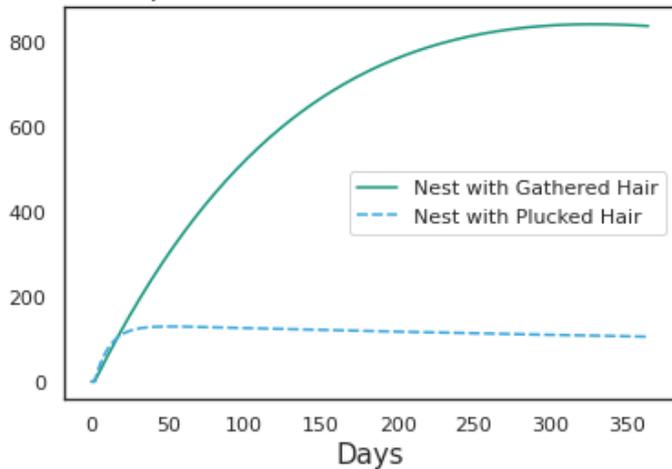
Ratio of Deaths of Birds Building a Nest - Subtropical Temperate



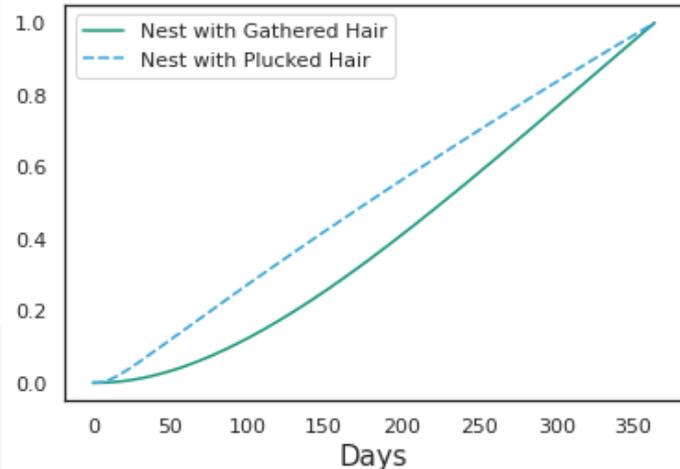
Population of Adult Birds Building a Nest - Subtropical Temperate



Population of Adult Birds with a Nest



Ratio of Deaths of Birds with a Nest



Other Benefits

- Protection from predators - scent
- Saves time
- Misguides lice



Future Work

- Gather more data on populations that pluck outside of the *Paridae* genus
- Dive into detail on the reasonings behind plucking hair over gathering

Acknowledgements

Dr. Vinodh Chellamuthu
SCUDEM

Sources

- animaldiversity.org/accounts/Paridae
- <https://esajournals.onlinelibrary.wiley.com/doi/10.1002/ecy.3501>
- <https://www.cbc.ca/radio/asithappens/as-it-happens-the-monday-edition-1.6126907/these-bold-little-birds-snatch-the-hairs-off-living-mammals-to-use-in-their-nests-1.6126985>