Pine Snake & Incubation Temperatures

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Problem Statement:

Will wider variations in temperature affect the Pine Snake population?

- Consider both overall size and gender dynamics

If so, how long will it take for these impacts to become noticeable?
Ask the Question

Variables:

- $R =$ Sex Ratio (Male:Female)
- $T =$ Incubation Temperature (Degrees Celsius)

Assumptions:

- One male and one female are needed for Pine Snake sexual reproduction
- Population starts at ratio of 1.0
- Temperature is normally distributed throughout the year
- Pine snakes all mate in the same season
- Eggs are laid in the summer (May, June, July, August)
Select the Modeling Approach

- Dynamic Model
  - This type of model will show the growth or decline of the sex ratio of Pine Snakes as temperature changes.

- Given Model
  - Sex Ratio $\approx 0.068 \times \text{Temperature} - 0.95$
    - Model has slight flaw
      - As Temperature increases the Sex Ratio increase infinitely
      - Point at which eggs will denature at some high temperature (35°C) and fail to hatch at some lower temperature (21°C)
Analysis of Old Model

- Assumptions:
  - Monthly temperatures are normally distributed
  - Mean and Variance were calculated from monthly data

- Data:
  - Gathered and synthesized from WeatherSpark.com

- Methodology:
  - Using R command of “rnorm” (created 100 random numbers)
  - Considered High and Low Temperatures for the months:
    - May
    - June
    - July
    - August
Graphs of the Model for May Data Set

Pine Snake Gender Ratio vs Low May Temperature

Pine Snake Gender Ratio vs High May Temperature

Legend:
- Green: 1:1 Sex Ratio
- Blue: Feasible Region of Low Temps
- Red: Feasible Region of High Temps
Formulate the Model

SexRatio ~ 0.068*(Temp) - 0.95
Formulate the Model

Average Sex Ratios Given Temperature

<table>
<thead>
<tr>
<th>dR/dT</th>
<th>R</th>
<th>T</th>
</tr>
</thead>
<tbody>
<tr>
<td>-0.385</td>
<td>0.5</td>
<td>24</td>
</tr>
<tr>
<td>0.205</td>
<td>0.885</td>
<td>25</td>
</tr>
<tr>
<td>-0.63</td>
<td>0.68</td>
<td>26</td>
</tr>
<tr>
<td>0.1</td>
<td>1.31</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>1.21</td>
<td>30</td>
</tr>
</tbody>
</table>
Formulate the Model

- When adjusting the model to be more accurate in predicting sex ratio, it did not make a significant difference.
- We used both a linear and logarithmic model for the data.
- Both trends are exactly equal.
Solve the Model

- This model predicts that male Pine Snakes will continue to dominate the Pine Snake population when the temperature is warmer (29 degrees Celsius +).
- Below 28 degrees Celsius is considered cold, and this is where females will begin to dominate the Pine Snake Population.
Answer the Question

Will wider variations in temperature affect the Pine Snake population?

- Yes, because colder weather leads to more females and warmer weather leads to more males. Having more females is not that problematic because one male can fertilize several females, but having few females will lead to an overall decrease in the population. Extreme temperatures (very hot or very cold) will lead to embryo death regardless of gender due to denaturation.

If so, how long will it take for these impacts to become noticeable?

- Using recursion, it is possible to see how long it takes. A more extreme temperature will make the impact more noticeable faster.
- Using the original model, after 10 years, at 28 degrees the ratio would be 0.624. At 29 degrees, the ratio would be 1.243.


Graphs of the Model for June Data Set

Pine Snake Gender Ratio vs Low June Temperature

Pine Snake Gender Ratio vs High June Temperature
Graphs of the Model for July Data Set

Pine Snake Gender Ratio vs Low July Temperature

Pine Snake Gender Ratio vs High July Temperature
Graphs of the Model for August Data Set

Pine Snake Gender Ratio vs Low August Temperature

Pine Snake Gender Ratio vs High August Temperature

Low Temperature of August (Celsius)

High Temperature of August (Celsius)