Abstract

Starlings overproduce females in response to high population density, which can allow for better fitness trade-off. But does the sex of the offspring itself affect the direct survival of the offspring. In this project, we found significance of the amount of females to the amount of eggs that survived into fledglings with one model, but no significance from another model. The mixed result could be due to factors such as data transformation and multicollinearity. Further investigation could reveal more about said subject

Introduction

In Rubalcaba, J.G. and Polo, V. (2022), it was found that a response to high density of nests causes starlings to produce more female offspring, an application of the sex allocation theory. In the study, it was predicted that in a high nest density area, more females will be produced, due to the males having higher variable fitness return, and females dispersing further outwards, lowering the density of the population. In our project however, we are going to look directly at how sex affects the amount of eggs that will persist into fledglings, without considering the density of the area, to see if having more females allows for more fitness to the eggs. The aim of this project is to analyze the effects the amount of females have on survival of eggs to finches. We predict that the amount of female and egg to fledgling to be positively correlated, and hypothesize that with the increase in the amount of female starlings, the amount of eggs that survive to fledglings also increases.

Methods

Data analysis was conducted using statistical and computational methods in R Studios in order to evaluate the relationship between our tested variables and to test our hypothesis.

Data Description

The data in this study is from Rubalcaba, J.G. and Polo, V, and was collected by using nest boxes on a colony of starlings, in Madrid Spain. The 48 nest boxes were scattered among trees in the flat pastureland.

The original data collected in this study consists of 11 columns, : Mother (mother ID), Treatment (low density vs high density), Year, Clutch (1st vs 2nd clutch), Date, Nest (nest ID), Eggs, Hatchlings (number of eggs hatched), Fledglings (number of fledglings 16 days after hatching), Males (amount of male hatchlings), Females (amount of female hatchlings). Character values are assigned to “Mother”, “Date” and “Treatment”. “Year”, “Clutch”, “Nest”, “Eggs”, “Hatchlings”, “Fledglings”, “Males”, and “Females” are integer values. The dataset comprises a total of 210 rows of gathered observations.

Data Analysis

Initially, cleaned our data to prepare it for testing, keeping only the columns needed to perform testing. We also transformed the data by adding new columns made from the original data: deaths (number of deaths), survival_rate (percentage survived to fledgling), and percent_female (percentage of females).

We initially wanted to use a linear regression model to model the data, but after analysing this data, we found it to be non-linear nor normally distributed. Thus, we decided to use a Poisson regression model. Using the generalized linear model (GLM) function, we made 2 models, a linear model, and a quadratic model. This allows us to perform model selection on the 2 models to see which one fits best for our data. Due to the change to a GLM with a Poisson regression, we decided to use Females and Fledgling numbers per observation as the predictor and response variable in our model, instead of the percent_female and survival rate values. A Poisson regression assumes non-negative values for the response variable, which is true here for the Fledgling amount, as well as independence of observation, which is met by data as well.

Results

The results shows a possible trend between number of females and number of fledgling (amount of eggs that survived into fledglings)

From the poisson regression GLM, we found a high statistical significance (p-value < 0.001) between the number of females and the number of fledgling from the linear model; the quadratic model, however, has a $p > 0.05$, making it not statistically significant.

From the 2 models, the resulting AIC score is <2, thus, a model cannot be chosen from this alone. And while the linear model shows statistical significance, the quadratic model better matches visually the observed data. Thus, we chose to keep the results of both in the report.

Discussion

The results of the Poisson regression model shows that there is a statistical significance for the amount of female's positive effect on the amount of eggs to fledglings when using the linear model, but not with the linear model. The linear model supports our prediction and hypothesis, while the quadratic model doesn't.

What is interesting is that, when compared to our quick analysis graph using survival_rate as the response variable, it is more usually similar to the quadratic model. This could be due to multicollinearity of the quadratic model, which could impact its significance, or just the nature of how the data was cleaned and transformed for the 2 graphs.

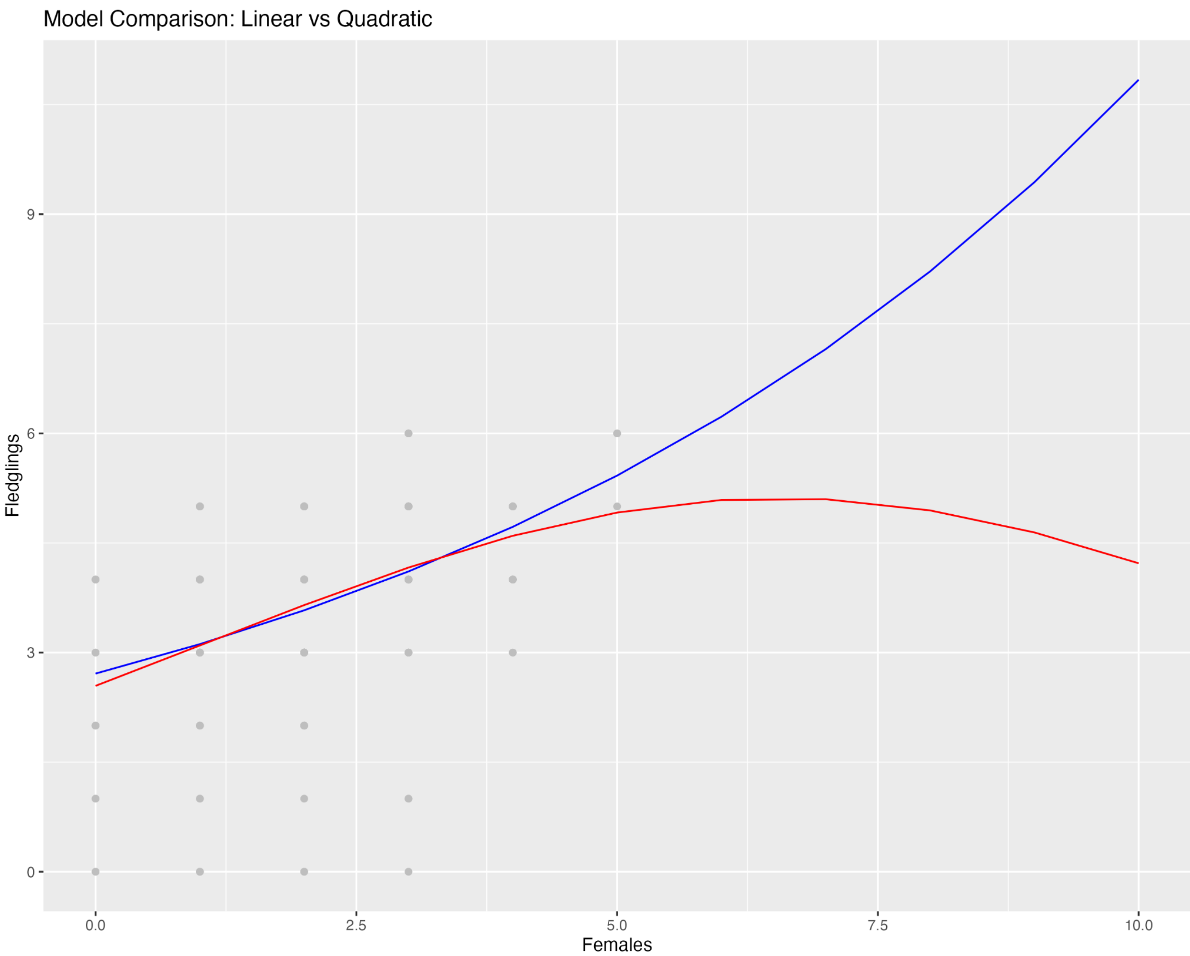

Figure 1. Model Comparison. The linear model supports our prediction, the quadratic model doesn't. The linear model shows an increase of eggs to fledging as the amount of females increases, while the quadratic model shows it falling off at around 6 females.

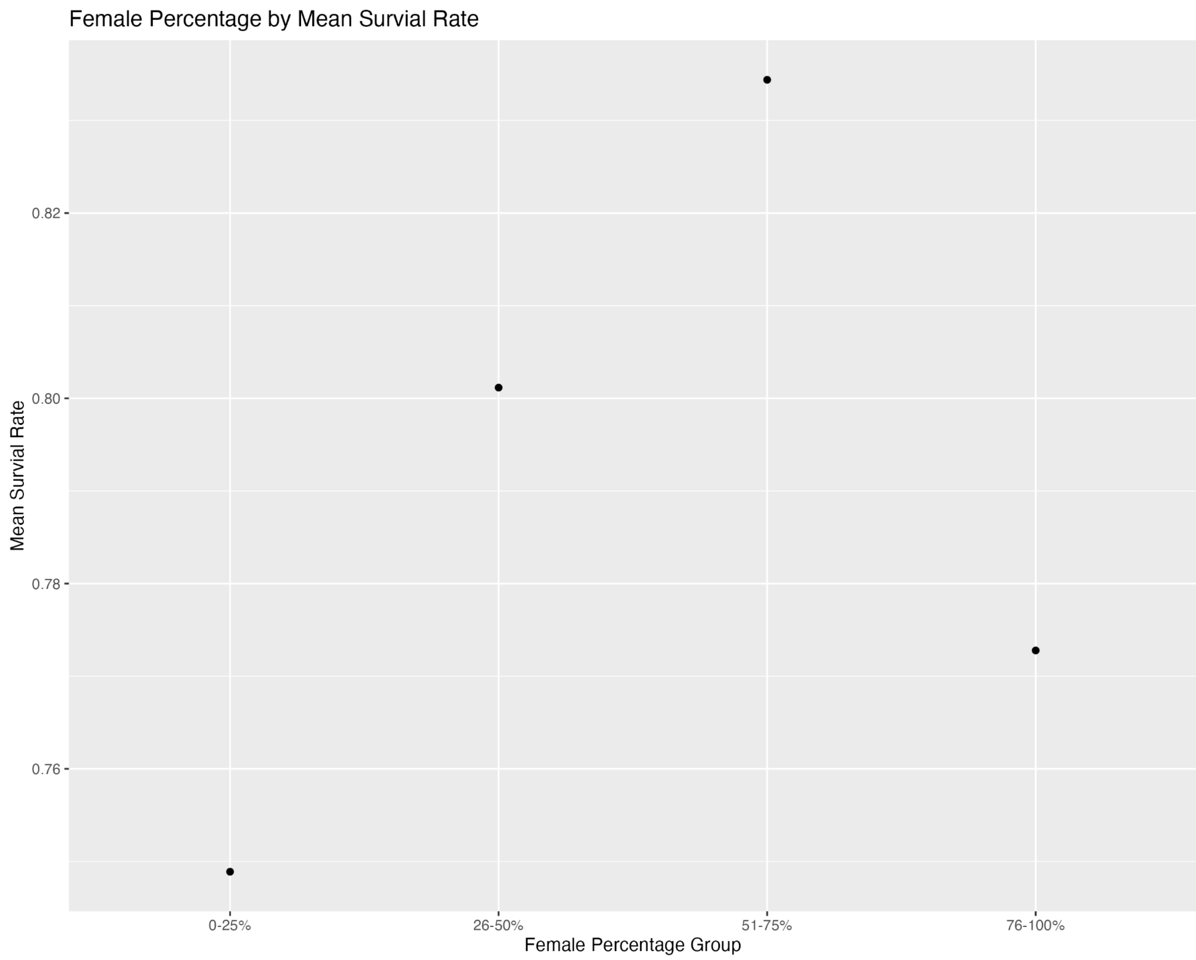

Figure 2. Similar to the quadratic model, a trend of a positive slope that falls was shown from our quick analysis

The potential explanation for the linear graph may be that due to females possibly having less variable fitness return, they have an overall higher mean fitness as compared to males. However, the result of this project could be limited by the data set used, and in the future, collection of new data may help to further understand the effects.

References

Rubalcaba, J.G. and Polo, V. (2022), Density dependence of clutch size and offspring sex ratio in starling colonies. J Avian Biol, 2022: e02993.https://doi.org/10.1111/jav.02993

Dataset: https://zenodo.org/record/6525052