Statistical Consulting Report

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Factors Influencing Black Rat Snake Depredation on Swainson's Warbler Nests

Swainson's Warbler (*Limnothlypis swainsonii*) is a species of high management concern across the southeastern US and few breeding biology research studies have been documented. There is a critical need of more studies for conservation and management implementation. Black Rat Snakes (*Elaphe obsoleta*) are the leading predator of Swainson's Warbler nests on the Roanoke River National Wildlife Refuge where data was collected.

The objective of this research project is to investigate what factors may influence Swainson's Warbler nest depredation by Black Rat Snakes. The hypothesis of this research is that cues or a combination of factors influence whether nests are depredated by Black Rat Snakes. Factors investigated include: number of trips made to and from nest by parents, nest height, time of year and day depredated, and host vegetation species of nest.

Methods

Data was collected from the Roanoke River National Wildlife Refuge from beginning of May until the end of July during the summers of 2007-2009. Infrared video cameras are installed at the nest when active nests are found by nest searching and then continuously monitored and recorded on a VCR tape until the nest either successfully fledges or the fails due to predation or other disturbance. Tapes were then analyzed by watching and documenting a time for all events at nest, including: incubation, brooding, feeding, hatching, watching, predation event, and any other events not within a specific category. Nests were randomly selected from the overall set of nests that had at least lasted until after the first two full days of nestling development and either had been predated by Black Rat Snakes (e.g. BRSN) or successfully fledged. Tape data from these selected nests were combined with the vegetation data collected in the field. This data set included: Nest ID, Number of Trips, Nest Height (m), Host Vegetation Type, Outcome of Nest (e.g. Y/N), and Date and Time of Predation. Number of trips during a two day period were counted from the tape data based on each flight by parents to and from nest during the first two full days after all nestlings were hatched. The date and time of predation were manipulated to fit a scale for easier analysis. These two scales are: 1-24 for the time of day, and 1-92 for the number of days within the field season from May 1st until July 31st for the time of year. Logistic regression model was used for data analysis.

Data summary

Table 1. Frequency and percent of for successful SWWA nests (N) and nests predated/failed by BRSN (Y).

Outcome	Frequency	Percent
N	16	55.17
Y	13	44.83

About 45% of the nests failed.

Figure 1. Distribution of the number of trips made by the birds for the first two full nestling development days shown as a percentage of the entire data set. On average, the birds make 125 trips to their nests.

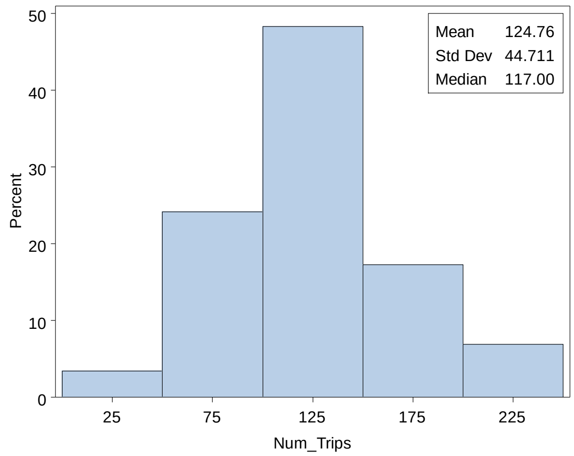


Figure 2. Nest height (m) distribution and basic statistics. The mean nest height was 1.079 m from the ground.

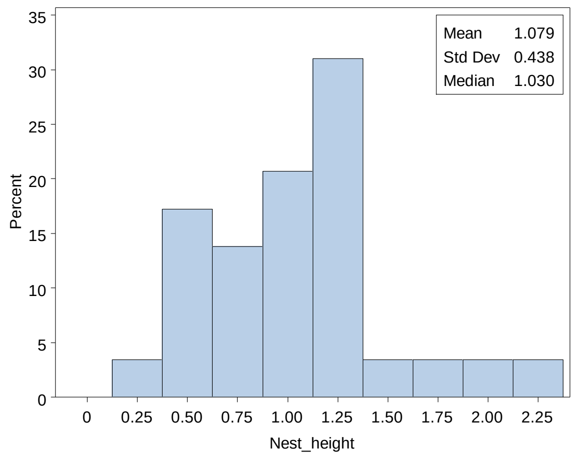


Figure 3. This is a distribution showing the day within the field season that nests were predated by BRSN, using the scale 1-92 for May 1st through July 31st. Successful nests were given a day of 92 (black bar).

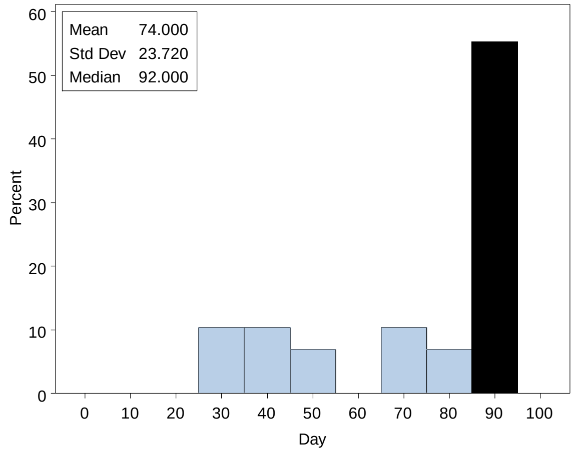


Figure 4. This histogram shows the time of day that nests were predated by BRSN, using a 24 hour scale, and successful nests are shown with a 0 (blue bar on left).

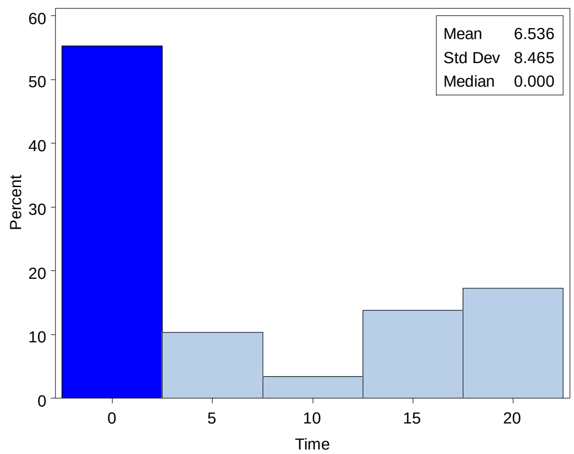
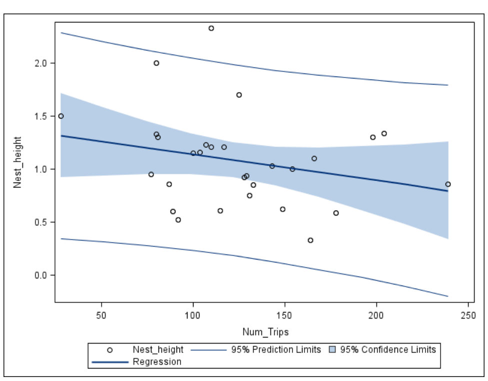


Figure 5. Is there a relationship between predictor variables nest height and number of trips made by the bird? The scatter plot (with fitted linear regression line) suggests that as the nest high increases, the birds tend to make fewer trips.



Data summary results

Out of 29 observed nests, 44% of the nests survived (13 out of 29). On average, the nest height was 1.08 m from the ground and the number of trips made to the nest was 125.

Statistical model

The response variable (nest survival) is binary. We are interested in the effects of trips to the nest made by the birds and nest height from the ground on survival. We fit a logistic regression model to predict the nest survival. In the model, the numbers of trips made to the nest and the nest height from the ground were used as predictor variables. The model is

$$\textbf{logit}(p_i) = \beta_0 + \beta_1\text{Height} + \beta_2\text{Trips} + \beta_3\text{Height*Trips}$$

Where logit (p_i)= logit transformation of the probability of the nest survival (YES, or failed outcome), β_0=intercept of the regression , β_1=parameter estimate of the Nest height, $\beta 2_1$=parameter estimate of Trips and β_3=parameter estimate of Height and Trips interactions.

Logistic regression results

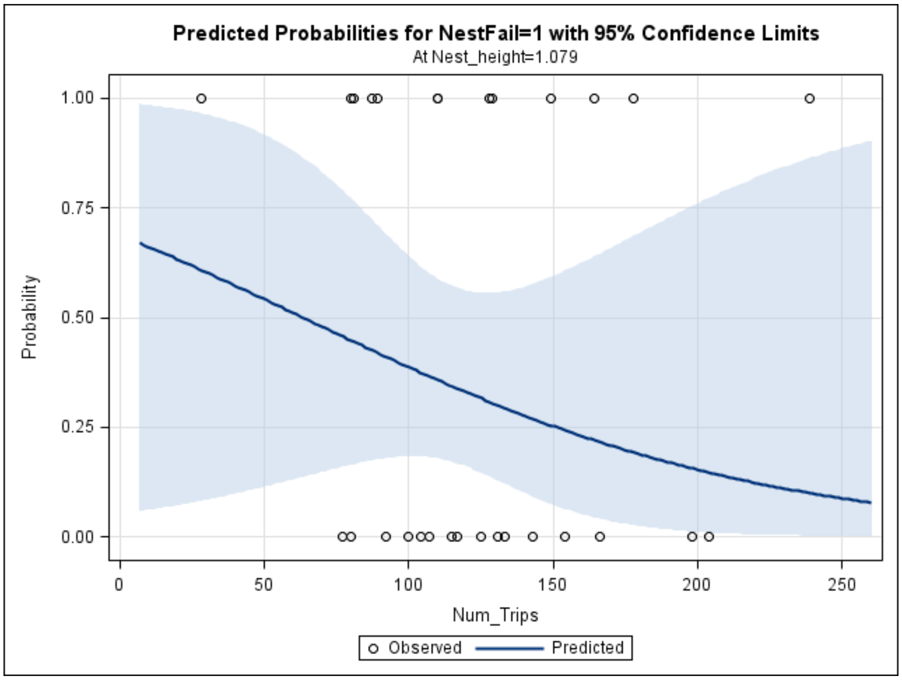
The overall model was significant at 0.0132 probability level suggesting that at least one parameter explains significant amount of variation in nest survival.

Testing Global Null Hypothesis: BETA=0			
Test	**Chi-Square**	**DF**	**Pr > ChiSq**
Likelihood Ratio	10.7395	3	0.0132
Score	8.5599	3	0.0358
Wald	4.5370	3	0.2090

The table of 'Analysis of Maximum Likelihood Estimates' showed that the main effects of nest height, number of trips and their interactions are all significant in explaining the nest survival.

Analysis of Maximum Likelihood Estimates					
Parameter	**DF**	**Estimate**	**Standard Error**	**Wald Chi-Square**	**Pr > ChiSq**
Intercept	1	-14.5929	6.8425	4.5484	0.0330
Num_Trips	1	0.1236	0.0581	4.5230	0.0334
Nest_height	1	14.2595	6.8438	4.3412	0.0372
Num_Trips*Nest_heigh	1	-0.1261	0.0602	4.3853	0.0362

If we keep the nest height constant at 1.079, number of trips has positive effect on nest survival (see figure below). As the number of trips increases, it is more likely for the nests to survive. Similar conclusions can made for the nest height effect as suggested by the estimate (14.2595) for this predictor variable.



The final model is

log(p/(p-1)= -14 + 3.44*Height+3.05*Trips - 0.1261Height*Survival

Conclusions

As the number of trips increased, the probability of nest failures decreased for a given constant nest height. However, more data are needed to further test this hypothesis as the confidence interval around the curve is large.

SAS Codes (version 9.2)

```
/* Enter data */
Data Nest ;
input NestID Outcome $ Num_Trips Nest_height  Time Day ;
datalines;
1      N      198   1.30  0.00  92
2      Y      128   0.92  16.49 38
3      Y      87    0.86  17.46 68
4      Y      28    1.50  20.31 51
5      Y      89    0.60  12.08 81
```

```
6     N     154   1.00  0.00  92
7     N     133   0.85  0.00  92
8     Y     239   0.86  13.11 34
9     N     166   1.10  0.00  92
10    N     107   1.23  0.00  92
11    Y     80    2.00  5.39  39
12    Y     81    1.30  20.52 38
13    N     104   1.16  0.00  92
14    Y     178   0.59  4.15  53
15    N     204   1.34  0.00  92
16    Y     164   0.33  5.42  65
17    N     143   1.03  0.00  92
18    N     92    0.52  0.00  92
19    N     117   1.21  0.00  92
20    Y     149   0.62  20.37 26
21    Y     110   2.33  21.14 33
22    N     131   0.75  0.00  92
23    N     115   0.61  0.00  92
24    N     100   1.15  0.00  92
25    N     125   1.70  0.00  92
26    N     77    0.95  0.00  92
27    N     80    1.33  0.00  92
28    Y     129   0.94  12.56 78
29    Y     110   1.21  20.54 70
;


/* create numeric response variable */
data nest; set nest ;
if outcome='Y' then NestFail=1;
if outcome='N' then NestFail=0;
run;

/* Examine the frequencies and percentages for nest survival */
proc freq ;
tables Outcome /norow nocol nocum ;
run;


/* Examine possible errors and generate histograms for the numeric
variables */
ods select  BasicMeasures histogram;
Proc univariate data=nest nextrobs=5 nextrval=5;
var Num_Trips Nest_height  Time Day;
   histogram Num_Trips Nest_height  Time Day /cfill=blue  ;
run;



/* Is there a relation b/w nest height and # of trips made? FIGURE 5*/
proc sgplot data=nest;
  scatter x=Num_trips y=nest_height ;
```

```
   reg x=Num_trips y=nest_height / CLM CLI;
run;


/* Generate logit values of response to examine relationships with the
predictor variables */
proc rank data=nest groups=3 out=ranks;
   var Num_trips;
   ranks bin;
run;

proc means data=ranks noprint nway;
   class bin;
   var NestFail Num_trips ;
   output out=bins sum(NestFail)=NestFail mean(Num_trips)=Num_trips;
run;


data bins;
   set bins;
   logit=log((NestFail+1)/(_freq_-NestFail+1));
run;

goptions reset=all;
proc sgplot data=bins;
   scatter y=logit x=Num_Trips / markerattrs=graphdata1(color=blue
                               size=10px symbol=circlefilled);
   xaxis label="Number of Trips";;
   yaxis label="Estimated Logit";
   title 'Estimated Logit Plot of Number of Trips Birds Made';
run; quit;
goptions reset=all;
proc sgplot data=bins;
   scatter y=logit x=Num_Trips / markerattrs=graphdata1(color=blue
                               size=10px symbol=circlefilled);
   xaxis label="Number of Trips";;
   yaxis label="Estimated Logit";
   title 'Estimated Logit Plot of Number of Trips Birds Made';
run;
quit;



/* Logistic Regression Model*/
proc logistic data=nest plots(only)=(effect(clband showobs)
              oddsratio (type=horizontalstat)) ;

model NestFail(event='1') = Nest_Height|Num_Trips/clodds=both rsq stb;
contrast 'Heigh vs Trips' Num_trips -25 Num_trips*nest_height -25
/estimate=exp;
contrast 'No interaction' Num_trips -25 / estimate=exp;
units Nest_height=1;
```

```
*  units Num_trips=25;
  oddsratio Nest_height  ;
* oddsratio Num_trips=25 Nest_height=.10 / default=1;
   title 'The effect of Nest Height and Trips on nest survival';
run;
```