<u>**The Effects of Seasonal Temperature and Precipitation Variation on the Productivity of Tree Swallows, *Tachycineta bicolor*, at the Beaverhill Bird Observatory, Alberta**</u>

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Abstract

Tachycineta bicolor (Tree swallow), an easily monitored avian species, were monitored over the summer of 2016 starting in May. A multitude of tree swallow nest boxes within three grids were monitored at the Beaverhill Bird Observatory, residing 9 kilometers east of Tofield, Alberta. These three grids are labeled as follows: the road grid, the spiral grid, and the weir grid. This study was undertaken to examine the differences/similarities between the nesting success of tree swallows occupying nest boxes in the grids aforementioned during a drought year (2015) and a wet year (2016). Our hypothesis states that *T. bicolor* nesting efforts have been negatively impacted by a much wetter nesting season in the summer of 2016. The accompanying prediction is that initially tree swallow nesting was aided by the arrival of an early spring but then later hindered due to inclement weather that came with increased precipitation throughout the summer. Statistical analysis of the spiral grid, which had data available for both 2015 and 2016, did not reveal a statistically significant difference between clutch size or fledgling success. However, between the three grids in 2016 statistically significant differences were noted using a single factor ANOVA; further studies could be carried out to determine the origin of these differences.

Introduction

The early arrival of migratory birds, such as tree swallows (*Tachycineta bicolor*), leads to earlier breeding (Kokko 1999). The benefits of earlier breeding, as observed across multiple avian species, suggests that early breeding is directly correlated with higher reproductive success (Kokko 1999). However, these early breeding benefits can be thwarted by seasonal temperature and precipitation fluctuations commonly associated with an early spring (Coe *et al*. 2015). Cooler temperatures and increased levels of precipitation have been reported to alter female tree swallow incubation behaviour often leading to the preference of self-maintenance over ideal and steady incubation temperatures (Coe *et al*. 2015). Suboptimal incubation temperatures have been shown to reduce nestling growth and fledging success in *T. bicolor* (Coe *et al*. 2015).

Tachycineta bicolor is an insectivorous migratory bird which most often lay only a single clutch of eggs (Monroe *et al*. 2008). Nests are lined with feathers to insulate and provide protection to the hatchlings which are hatched altricial. The hatchlings typically fledge after 18 to 20 days (Nooker *et al*. 2005). The typical nesting season for tree swallows is as early as April for birds farthest south and ranges from May to July for birds nesting in the northern extreme (Winkler *et al*. 2013). In May of 2016 the weather station located in Elk Island National Park, 40 km north-west of the Beaverhill Bird Observatory (BBO), reported a total precipitation amount of 125.8 mm in May 2016, compared to precipitation levels of 37.3 mm in May of 2015 (Government of Canada 2016). The mean temperature did not vary drastically from 2015 to 2016, although 2016 did have a slightly higher average temperature in May (Government of Canada 2016).

Tree swallows are highly social and tend to flock in large numbers. They often utilize man-made nest boxes and are tolerant of repeated disturbances by researchers (Jones, 2003 as cited in Winkler et al., 2013). These traits make *T. bicolor* extremely useful for scientific study.

Data were collected and analyzed in order to compare reproductive success of *T. bicolor* over a two-year span of dry and wet springs respectively. This was done in order to test our hypothesis that heavy precipitation will have a negative effect on nestling success despite the assistance of an early spring. We predict that the presence of an early spring in 2016 will lead to higher initial success in tree swallow reproduction; however, the increased precipitation will lead to higher fledging mortality rates.

Methods

Data were collected during the summer of 2016 over a three-month period from May to the end of July/beginning of August, depending on the grid being surveyed. Nest boxes belonging to the Beaverhill Bird Observatory were checked once per week during the nesting season of the *T. bicolor*. There were three grids monitored during this time: the Road, the Spiral, and the weir grids. These three grids are all part of the BBO field laboratory that is on a provincially designated natural area south of Beaverhill Lake, located approximately 9 kilometers east of Tofield, Alberta.

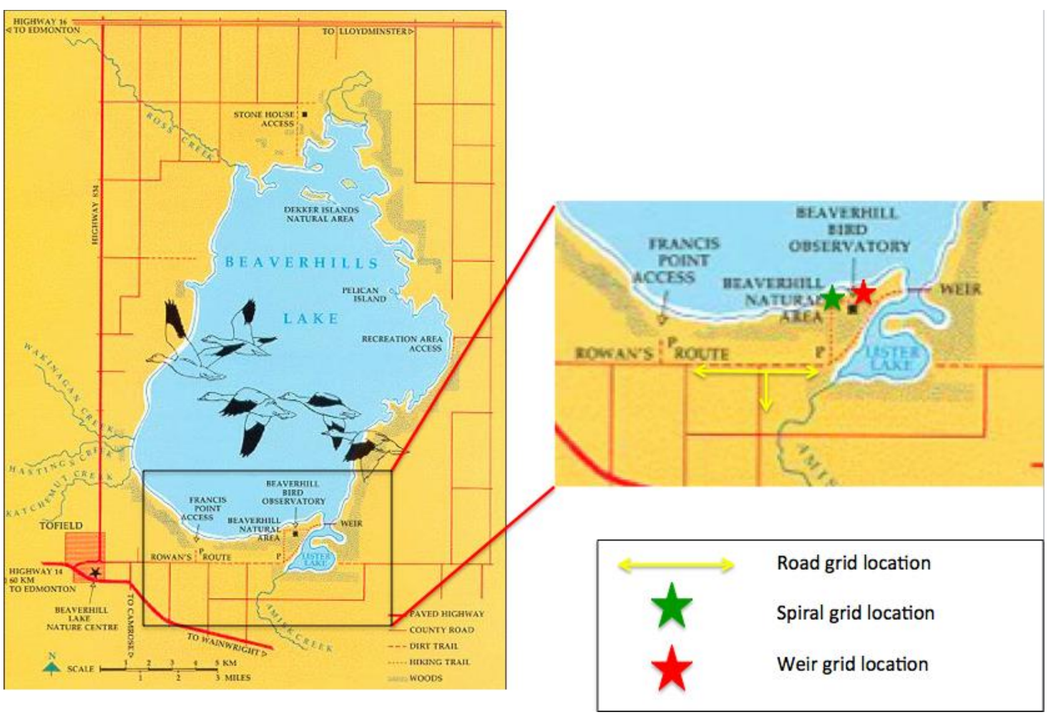

Figure 1. Beaverhill Lake map depicts the locations of the road, spiral, and weir grids. This map is a modified version of the Beaverhill Lake Area Map. http://beaverhillbirds.com/directions.php

Nest boxes were all attached to either a pole or a fence post and were accessible by completely removing the lid of the box for inspection, or, by lifting up the side of the nest box without the ability to completely remove it. The height at which each nest box was fastened to the pole was between 1 and 2 meters and the direction that each nest box opening faced varied from west to south to east but never north.

Figure 2. Example of nest box from the weir grid

Nest boxes were initially checked to see if a nest was present. Next, data was recorded based on the completeness of the nest: ‘G’ represented the presence of grass in the nest box, ‘C’ showed that the nest was in a cup shape, and ‘L’ meant that the nest had been lined with feathers. After the first egg was laid, data was recorded solely on the presence of eggs and the number of young. The nestlings were recorded based on number, but also on age, this allowed for the banding of the *T. bicolor* chicks after they were confirmed to be past the age of 12 days.

Figure 3. Left photo showing a nicely formed grass cup with a heavy feather lining. Right photo shows newly hatched chicks at the beginning of the monitoring period.

After data collection was complete the data were compiled and a single factor ANOVA was used to compare the mean for clutch size and fledgling success. The comparisons were done between all three grids checked in 2016, as well as, data collected in 2015 (drought year) compared to 2016 (wet year) for the spiral grid.

Results

There were three different grids monitored once a week. These grids were known as: the road, the spiral, and weir grid. The spiral and road grid were monitored from May 24, 2016 to July 25, 2016, with the exception of the week of July 10 due to excessive rainfall. The weir grid was monitored from May 24, 2016 to August 4, 2016, with the exception of the week of July 10 due to the flooding of the lake bottom the grid resides on. Out of a possible 66 nest boxes along the road, there were 56 total clutches. Four of the 56 clutches were double clutches and occurred in nest boxes 1X, 2, 3, and 28. In each of these nest boxes the first clutch was unsuccessful and the second clutch resulted in healthy fledglings for boxes 1X, 2, and 3. The second clutch of eggs present in nest box 28 disappeared after only one week. Out of the total successful clutches, the average number of fledglings was 5.459. There were 10 nest boxes that contained eggs that disappeared before they hatched; these eggs were most likely lost to predators such as deer mice, which took over seven nest boxes in total. Nest boxes 8 and 12 had eggs remain constant for weeks and never fell victim to predation. Box 16X and 28 contained clutches that all perished before fledging; these were cleaned out and box 28 had a second (unsuccessful) clutch.

The spiral grid was comprised of 90 total nest boxes; 67 of these boxes supported tree swallow clutches. Box #2 had the only double clutch for tree swallows after the first clutch was unsuccessful. The average number of fledglings was 5.80 young. There were also 11 boxes occupied by wrens and box number 40 had two clutches of mountain bluebirds.

The weir grid had 50 total nest boxes; all 50 supported clutches throughout the 2016 nesting season. Only nest box number 11 boasted 2 clutches throughout the monitoring period after having an unsuccessful clutch the first time. The average clutch size was 6, and the average number of fledglings was 5. Nest boxes 15 and 29 each had a single dead nestling left behind.

A single factor ANOVA was run on Microsoft Excel 2007 and was used to compare the clutch size and number of successful fledglings in all three grids as well as data collected in the spiral grid between 2015 and 2016.

Table1. Single factor ANOVA analyzing clutch size between grids in 2016

Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
(S) clutch '16	69	429	6.217391	1.231458		
(R) clutch '16	59	325	5.508475	2.90941		
(W) clutch '16	50	325	6.5	1.193878		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	29.33533	2	14.66767	8.253911	0.000375	3.047605
Within Groups	310.9849	175	1.777057			
Total	340.3202	177				

When comparing clutch size of all three grids from the 2016 data, we find that the calculated F-value (8.253911) is greater than the critical F-value (3.047605) and the P-value (0.000375) is less than 0.05. These results indicate that the difference in means between groups is statistically significant.

Table 2. Single factor ANOVA analyzing fledgling number between grids in 2016

Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
(S) # fledglings '16	69	389	5.637681	2.616795		
(R) # fledglings '16	59	225	3.813559	7.395675		
(W) # fledglings '16	50	279	5.58	2.615918		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	127.8783	2	63.93913	15.22213	8.04E-07	3.047605
Within Groups	735.0712	175	4.200407			
Total	862.9494	177				

When comparing fledgling number of all three grids from the 2016 data, we find that the calculated F-value (15.22213) is greater than the critical F-value (3.047605) and the P-value (8.04×10^{-7}) is less than 0.05. These results indicate that the difference in means between groups is statistically significant.

Table 3. Single factor ANOVA analyzing clutch size in the spiral grid in 2015/2016

Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
(S) clutch '16	69	429	6.217391	1.231458		
(S) clutch '15	53	316	5.962264	0.883164		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1.951095	1	1.951095	1.805683	0.181562	3.920124
Within Groups	129.6637	120	1.08053			
Total	131.6148	121				

When comparing clutch size data collected on the spiral grid between 2015 and 2016, we find that the calculated F-value (1.805683) is less than the critical F-value (3.920124) and the P-value (0.181562) is greater than 0.05. These results indicate that the difference in means between groups is not statistically significant.

Table 4. Single factor ANOVA analyzing fledgling number in the spiral grid in 2015/2016

Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
(S) # fledglings '16	69	389	5.637681	2.616795		
(S) # fledglings '15	53	288	5.433962	2.865747		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1.244021	1	1.244021	0.456576	0.500529	3.920124
Within Groups	326.9609	120	2.724674			
Total	328.2049	121				

When comparing fledgling number data collected on the spiral grid between 2015 and 2016, we find that the calculated F-value (0.456576) is less than the critical F-value (3.920124) and the P-value (0.500539) is greater than 0.05. These results indicate that the difference in means between groups is not statistically significant.

Discussion

The data analysis comparing both clutch size and fledgling success between 2015 and 2016 showed that there was not a significant difference between the means despite the substantial increase in precipitation levels; 2015 was a dry year with lower precipitation levels and 2016 had an increase in average precipitation of 88.5 mm in the month of May. Average temperatures between the two years remained relatively similar and could account for the similar averages between the years.

Analysis of data collected in 2016 showed that there was a significant difference between the means of the road grid, weir grid, and the spiral grid. Further analysis must be done in order to determine if all grids differ from each other or if a single grid is responsible for the significant difference. Possible reasons for differences between grids could be: high numbers of field mice predation along the road, increased traffic disturbances along the road, limited human and vehicular disturbances in the weir grid, and/or the noticeable increase in house wren nests in the spiral grid which reduced the number of nest boxes available for tree swallow nestlings.

Based on the result of the ANOVA on the spiral grid data from 2015 and 2016, we reject our hypothesis that the presence of an early spring in 2016 would lead to higher initial success in tree swallow reproduction in all grids but the increased precipitation would lead to higher fledging mortality rates when compared to data collected during a dry year such as 2015.

While the spiral grid showed no significant difference between years, it would be unwise to assume all grids follow the same pattern. Further research and data analysis is needed in order to accurately confirm or deny our thesis. Lack of data records from the road and weir grids in 2015 hindered such analysis.

Conclusion

We predicted that the presence of an early spring in 2016 would lead to higher initial success in tree swallow reproduction in all grids but the increased precipitation would lead to higher fledging mortality rates when compared to data collected during a dry year. The single factor ANOVAs that were done determined that there was not a significant difference between the means of clutch size or successful fledgling numbers between 2015 and 2016. There was, however, a significant difference when comparing data from all three grids monitored in 2016. One of the main differences between the grids is the varying levels of human activity and interference. While further testing must be done to determine which grid(s) are significantly different for the 2016 season, we know that there was not a significant difference in tree swallow success between wet and dry seasons in the spiral grid.

Recommendations

Even though our study did not reveal differences in nesting success of tree swallows between wet and dry years, it has been noted in previous studies. Therefore, it is recommended that monitoring of the three grids at the Beaverhill Bird Observatory continue to analyze the impact inclement weather has on clutch sizes and fledgling success. It is also recommended that further examination go into revealing the reasons for the statistically significant differences in productivity of tree swallows between the three grids. Finding the determinants of these differences in productivity could mean increasing the nesting success of tree swallows by implementing certain, yet to be determined, measures.

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