The Drying of Beaverhill Lake and its Effects on the Clutch Size of Tree Swallows, *Tachycineta bicolor*, at the Beaverhill Bird Observatory, Alberta

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Abstract

Tachycineta bicolor has been renowned in avian research as it has many qualities similar to that of a model organism for study. The eagerness of *T. bicolor* to occupy nest boxes makes this species readily available for research and observation. *T. bicolor* has been studied at the Beaverhill Bird Observatory, located a few kilometers east of Tofield, Alberta, for a couple decades originating in the grid now known as the "old Tree Swallow grid". This grid originally resided just off the lakeshore, but now after the drying of the lake, to the north of the grid is open grassland meadow and to the south is encroaching aspen forest. This study was undertaken to examine the effect the drying of the lake had on nesting *T. bicolor.* The old grid allows for a unique opportunity to examine the reproductive efforts prior to and after the drying of the lake and the changes that have taken place. In particular this study looks to analyze the changes in average clutch size over a 15-year period (2000-2015). My hypothesis states that *T. bicolor* clutch sizes have been negatively affected by the environmental change that is the drying of Beaverhill Lake. The accompanying prediction is that clutch sizes have been reduced from the optimum due to a decrease in abundance of flying insects that once flourished over the shallow waters of the lake. With a decrease in food abundance it is thought that the increase in both inter-brood and intra-brood competition for food have shifted clutch sizes below the optimum. Results illustrate the decline of clutch sizes over

time and predict a 0.0251 decline of eggs in each clutch/year. Although this negative trend is prevalent the trend itself is not statistically significant ($p = 0.94$). Further examination into the effects the drying of the lake had on this species can reveal more reproductive, and perhaps behavioral changes, which have taken place since. This study is relevant in a world where drought caused by climate change is not uncommon as it depicts, on a small scale, how the elimination of a water body alters avian species in need or relying on its presence.

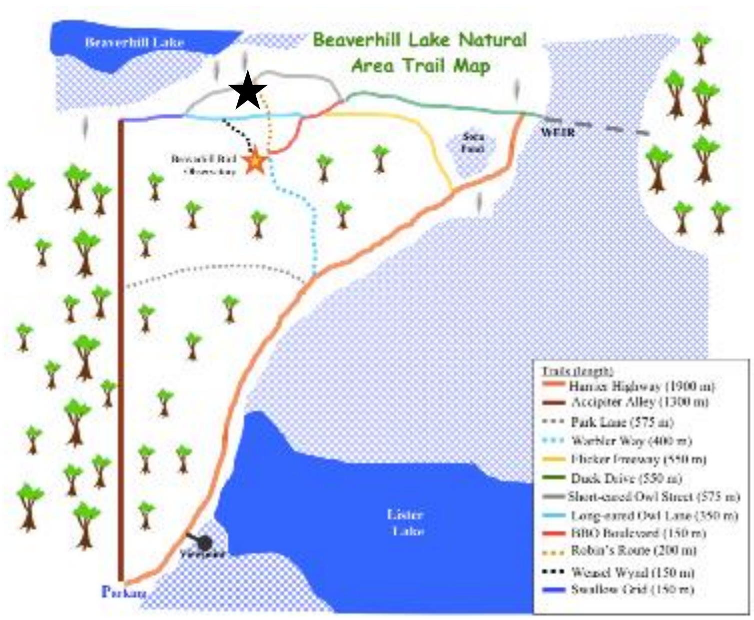
Introduction

Since all organisms can only obtain or have access to a finite supply of energy, organisms must partake in tradeoffs. Tradeoffs must be made between the number of offspring, offspring size, and their survival (Molles and Cahill 2014). These tradeoffs involving reproduction offer insights into the realm of parent-offspring conflict (Kilner and Drummond 2007). Conflict arises between parents and offspring when what is ideal for the brood is not ideal for the parents. Parent-offspring conflict is a common occurrence in avian families. Two forms of parent-offspring conflict are apparent; these two forms are inter-brood conflict and intra-brood conflict. Inter-brood conflict arises when offspring subtract from the parental investment being withheld by the parents for future broods. Intra-brood conflict arises when the current brood has a different ideal division of investment than that of the parents, leading to sibling competition (Kilner and Drummond 2007). These conflicts arise when offspring begin demanding additional resources by the feeding parents and therefore, would increase with the decline of food abundance. With the reduction of food availability sibling competition will increase, and as a result, the presence of sibling competition may trigger the selection of smaller clutches over the optimum clutch size (Godfray and Parker 1992).

The Tree Swallow (*Tachycineta bicolor*) is a common avian insectivore that spends summers in open landscapes in North America. Tree Swallows are a cavity nesting species that lay 4-6 eggs in a nest cup composed of grass, forbs, and feathers (Fisher and Acorn 1998). Tree Swallows have been referred to as a new model organism due to their ready availability, tractability, fairly short generation time, and smaller adult size. Tree Swallows eagerly breed in nest boxes and are therefore readily available and tractable as a study organism (Jones 2003). Tree Swallow nest boxes were observed over the summer months and compiled with past data to test the hypothesis that Tree Swallow clutch sizes have been affected by the environmental change that is the drying of Beaverhill Lake. It is predicted that average clutch sizes have been reduced with the drying of the lake due to the depletion of flying insect populations that were once abundant over the shallow water. This study has relevant information about sibling competition caused by reduced food abundance and the corresponding change in clutch sizes in a unique natural setting.

Methods

This study was undertaken during the summer of 2015 to observe the changes of clutch size at the Beaverhill Bird Observatory (BBO). The BBO field laboratory resides in a provincially designated natural area just south of the original lakeshore of the now dry Beaverhill Lake and is located approximately 9 km east of Tofield, Alberta (Figure 1). This study was conducted in the 'old Tree Swallow grid', which is composed of 48 of the original nest boxes and another 42 newly added nest



boxes (Figure 2).

Figure 1: Beaverhill Lake Natural Area Trail Map. The black star on the blue line corresponding to 'Swallow Grid' on the map legend is the location of the old Tree Swallow Grid. Map is a modified version of Beaverhill Bird Observatory PDF Trail Map. http://beaverhillbirds.com/docs/bbo_trailmap.pdf

All nest boxes are on metal poles. The original nest boxes open from the top and the new nest boxes are side opening. The height the nest boxes, the direction each nest box faced, and the distances between all of the nest boxes varied.

Figure 2: An example of the new Tree Swallow nest box. Photo taken by Jordan

Nakonechny at the BBO.

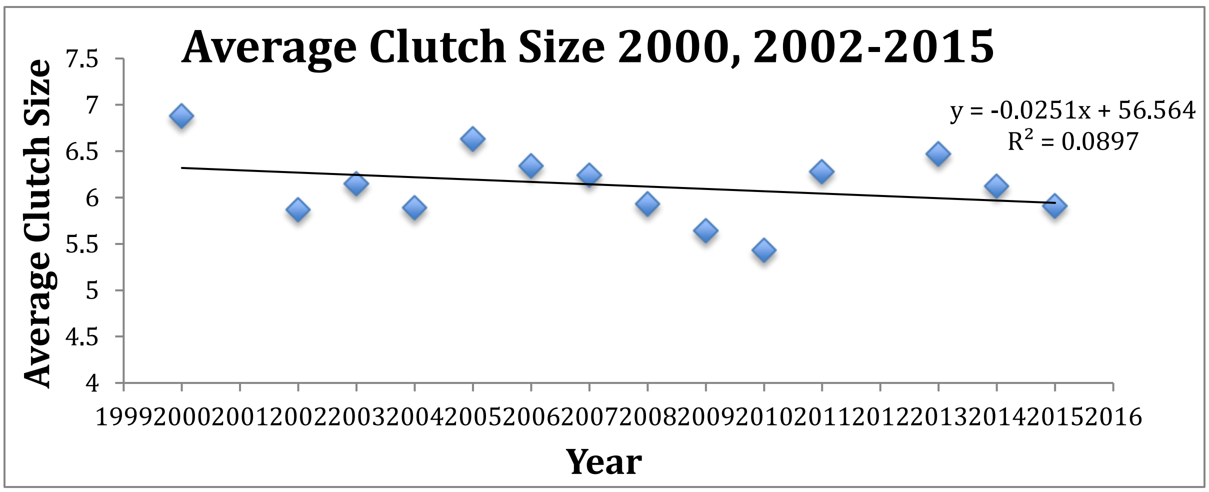
Nest box checks began May 23rd, 2015. Each nest box check consisted of determining whether a nest was present (E – Empty, P – Partial, C- Complete, C-# - Complete with number of feathers, and CFL – Complete feather lining), the type of nest (Tree Swallow (TRES) – grass nest cup with feathers and white eggs, Mountain Bluebird (MOBL) – grass nest with blue eggs, and House Wren (HOWR) – twig nest with pink eggs (Figure 3)), the number of eggs and number of nestlings, the age of the young, and whether the young was ready to fledge. Once the young were close to fledging they were banded and when the young had left the nest the box contents were emptied. The data collected during the summer of 2015 was then compiled with past data and analyzed using Microsoft Excel. Average clutch size for this summer was calculated and used with past average clutch sizes to try and detect trends overtime using a linear regression. Data used dates back to the year 2000. This year was chosen as an endpoint since marks roughly the middle of the drying period of Beaverhill Lake. The lake was completely dry by the year 2006 (Priestley and Priestley 2011).

Figure 3: Comparison of the nests of, left to right, Tree Swallow, Mountain Bluebird, and House Wren. Photos taken at the Beaverhill Bird Observatory by Jordan Nakonechny.

Results

A total of 56 nest boxes contained a clutch. It should be noted that nest box 27 had two clutches over the span of the summer, for a total of 57 different clutches. The second clutch appeared after the previous young had fledged. The date of the first egg being laid was estimated by backdating one egg per day from the first nest recording, the corresponding average date of nest initiation is estimated as May 20th, 9 days earlier than the previous year. The last clutch initiation date in 2015 was estimated to be July 1st, this clutch was the second observed in nest box 27. The minimum clutch size for 2015 was 4 eggs and the maximum clutch size was 9 eggs. The mode of all clutch sizes was 6 eggs as 46% of all clutches laid had this amount of eggs. The mean clutch size for 2015 was 5.91 ± 0.95 (n=57) and can be compared to the average clutch sizes of 2013 and 2014, respectively, 6.47 ± 0.8 (n=34) and 6.12 ± 1.3 (n=33). This year's average clutch size depicts a 4% decline from 2014's average clutch size. Although the regression analysis of the old Tree Swallow grid (Figure 4) from 2000-2015 reveals a trend of decreasing clutch sizes over the years the trend itself is not significant (n=482, R^2 = 0.08968, p = 0.94, slope = -0.0251).

Figure 4: Average clutch sizes in relation to year. Trend line from regression analysis (n=482, R^2 = 0.08968, p = 0.94).



Discussion

The hypothesis in this study stated that clutch size has been altered due to the drying of Beaverhill Lake. Specifically, it was predicted that the average clutch size of Tree Swallows has been gradually reduced since the year 2000. This was predicted due to the depletion of shallow water habitat used by insects; thus it can be assumed a reduced insect population over the years, or prey, for Tree Swallows. An article reaffirmed this hypothesis whose findings stated that with an abundance of insect prey female Tree Swallow's produced larger clutches (Nooker et al. 2005).

The analysis of the nest box data from 2000-2015 revealed a decreasing trend that was not statistically significant ($p = 0.94$). The results, although not statistically significant, depict a decline in the clutch size of Tree Swallows over the years. For every subsequent year the average clutch size was reduced by 0.0251 eggs ($y= -0.0251x + 56.564$) or 0.4 egg over 15 years. This represents about a 6% decline in productivity, which may be biologically significant.

During the span of this study there was evidence of intra-brood conflict leading to sibling competition. In nest box 6 a single hatchling was found deceased amongst the rest of the hatchlings. The hatchling that was deceased was a smaller size than its siblings. Nest box 70 revealed 5 dead young, however, the sixth young was not present. While nest box 6 and 70 depicted situations where the young had not left the nest, nest boxes 79 and 88 contained a single dead fledgling each. The cause of death of these fledglings was presumably starvation.

Inter-brood conflict can also be expected from the examination of the data collected. For example nest box 39 boasted an impressive clutch size of nine and the successful fledging of all of the young. A study has suggested that the true threshold for parental care takes place with a clutch size of nine. A clutch size this large exceeds a normal clutch size by 50-80% (Murphy et al. 2000). This finding was consistent with models of parental care that include the assumption that both clutch size and the behavior of parents reflect the equal value of both the current brood and future broods. From this, it can be said that a clutch size of 9 is relatively rare since a clutch of that size significantly reduces the possible parental care available to future broods. The evidence of intra-brood conflict points to the reduced abundance of insects due to lake drying, and therefore, the increase of sibling competition. Consequently, clutch sizes were lowered from the optimum. With evidence of inter-brood conflict, it can be assumed that clutch sizes were reduced due to the depletion of total parental care for future broods. This depletion of parental care is due to the excessive feeding demands, observed as repeated "begging calls", of the current brood in a habitat with reduced insect prey populations. These two conflicts contributions to the clutch size changes observed temporally are shown by this study, and therefore, clutch sizes should continue to be monitored to further understand how reproductive effort is influenced by these conditions.

Conclusion

These results portray that with the presence of both inter-brood and intra-brood competition, clutch sizes of Tree Swallows have been negatively affected at the Tree Swallow grid located on the edge of Beaverhill Lake. It is thought that with the depletion of water from the lake in the early 2000's the flying insect populations were also depleted, altering the available prey sources for the nesting Tree Swallows. Energy and parental care must be rearranged with a more limited supply of food available, moving clutch sizes away from the optimum. The data analyzed in the timeline observed for this study supports the idea of a reducing clutch size in response to the lake drying. Though statistical analysis does not reveal a significant negative trend, it is important to note that clutch sizes, for the most part, continue to decline over the last 15 years.

Recommendations

Although the analysis of data from 2000-2015 did not reveal a significant result the indication of inter- and intra-brood conflict altering clutch size should not be taken lightly and monitoring should continue through this period of reproductive decline at the Beaverhill Bird Observatory.

Other recommendations would be the repair of nest boxes. The following nest boxes in the old Tree Swallow grid are in good condition: 1-7, 9, 10, 12-19, 22, 24, 25, 27, 28, 31-33, 35, 37-40, 42-45, 47, 48, 51-53, 55, 56, 58-65, and 67-92. The following nest boxes in the grid are in need of more wire: 11, 20, 21, 26, 30, and 46. The following nest boxes are in need of screws for wire attachment: 20, 29, and 34 (29's back panel is also starting to separate). The following nest boxes lack 1 of 2 back braces: 36, 41, 54, 57, and 66. Nest box number 8 is in need of a new bottom board and the pole that number 23 rests on is rather loose. By completing these needed repairs nest box checks would become easier and more fluent in 2016.

Acknowledgements

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Literature Cited

Fisher C, Acorn J. 1998. Birds of Alberta. Edmonton (AB): Lone Pine Publishing. Owls; p. 244.

Godfray HCJ, Parker GA. 1992. Sibling competition, parent-offspring conflict and clutch size. Animal Behavior. [accessed 2015 Jul 31]; 43(3): 473-490. http://www.sciencedirect.com/science/article/pii/S000334720580106X?np=y

Jones J. 2003. Tree Swallows (*Tachycineta bicolor*): a new model organism? Auk. [accessed 2015 Jul 31]; 120(3): 591-599. http://www.jstor.org/stable/4090091?seq=1#page_scan_tab_contents

Kilner RM, Drummond H. 2007. Parent-offspring conflict in avian families. Journal of Ornithology. [accessed 2015 Jul 31]; 148(2): 241-246. http://link.springer.com/article/10.1007/s10336-007-0224-3

Molles MC, Cahill JF. 2014. Ecology concepts and applications. 3rd ed. Whitby (ON): McGraw-Hill Ryerson.

Murphy MT, Armbrecth B, Vlamis E, Pierce A. 2000. Is reproduction by Tree Swallows (*Tachycineta bicolor*) cost free?. Auk. [accessed 2015 Jul 31]; 117(4): 902-912. http://pdxscholar.library.pdx.edu/cgi/viewcontent.cgi?article=1071&context=bio_fac

Nooker JK, Dunn PO, Whittingham LA. 2005. Effects of food abundance, weather, and female condition on reproduction in Tree Swallows (*Tachycineta bicolor*). Auk. [accessed 2015 Jul 31]; 122(4): 1225-1238. http://aoucospubs.org/doi/full/10.1642/0004-8038(2005)122%5B1225%3AEOFAWA%5D2.0.CO%3B2

Priestley L, Priestley C. 2011. Eyes on IBAs: Beaverhill Lake IBA site number 001. Nature Alberta 40: 10-13.

Appendix I - Statistical Analysis

Linear Regression

Regression Statistics

R	0.024
R Square	0.00058
Adjusted R Square	-0.09028
S	0.34711
Total number of observations	13.00

6.88 = 9.8649 - 0.0019 * 2000

ANOVA

	d.f.	*SS*	*MS*	*F*	*p-level*
Regression	1.	0.00076	0.00076	0.00634	0.93796
Residual	11.	1.3253	0.12048		
Total	12.	1.32607			

	Coefficients	*Standard Error*	*LCL*	*UCL*	*t Stat*	*p-level*
Intercept	9.86494	47.61643	-94.93812	114.668	0.20718	0.83966
2000	-0.00189	0.02371	-0.05407	0.0503	-0.07963	0.93796

T (5%) 2.20099

LCL - Lower value of a reliable interval (LCL)

UCL - Upper value of a reliable interval (UCL)

Residuals

Observation	*Predicted Y*	*Residual*	*Standard Residuals*
1.00	6.08512	-0.21512	-0.64731
2.00	6.08323	0.06677	0.20091
3.00	6.08134	-0.19134	-0.57577
4.00	6.07946	0.55054	1.65663
5.00	6.07757	0.26243	0.78968
6.00	6.07568	0.16432	0.49445
7.00	6.07379	-0.14379	-0.43268
8.00	6.0719	-0.4319	-1.29963
9.00	6.07002	-0.64002	-1.92586
10.00	6.06813	0.21187	0.63754
11.00	6.06435	0.40565	1.22062
12.00	6.06246	0.05754	0.17313
13.00	6.06058	-0.09694	-0.2917

Appendix II – Raw Data is in a separate file