

The Effects of Varying Seasonal Precipitation Levels on the Reproductive Success of *Tachycineta bicolor* (Tree Swallow)

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Abstract

Climatic changes are of increasing concern to migratory avian species. Long-term shifts in temperature, weather patterns, humidity, precipitation, and other factors could drastically impact the lives of various bird species. These parameters could lead to changes in food availability, quantity of predators, reproductive output and success, and ultimately affect survival rates. The objective of this research experiment was to determine if an increase in seasonal precipitation has a negative effect on the breeding success of the Tree Swallow. This study was carried out on the road grid at Beaverhill Bird Observatory (BBO), located 9 kilometers east of Tofield, Alberta. Various breeding parameters were assessed over the three month nesting period from May to July, 2017. The average clutch size and number of developed fledglings from a wet year (2016) and a dry year (2017) were compared to determine if seasonal precipitation had any effect on reproductive success of the swallows. It was hypothesized that in 2016 when precipitation rates were higher in the months of May, June, and July, both the clutch size and survival rate of fledglings would increase, due to increased food availability. These hypotheses were disproved, as clutch sizes were larger in the dry year, and there was no difference in brood size means between the wet and dry years. It was concluded that more studies need to be conducted in order to better understand individual species' requirements when it comes to optimal conditions to yield the greatest reproductive success.

Introduction

Established in 1984, the BBO is located in a provincial natural area used for research, recreation, and education (Darren McGregor, n.d.). The observatory promotes the conservation and long-term preservation of avian species, emphasizing the protection of migratory birds. Continuing data sets enable long-term monitoring of various avian species, which allows researchers to identify changes in bird populations, ecology, migratory ranges, and reproductive success (Darren McGregor, n.d.).

Migratory birds are known to be especially sensitive to changing climatic conditions (Government of Alberta, 2012). Increased seasonal precipitation rates strongly influence the abundance of arthropods in Alberta, directly affecting the life processes of avian species that rely on insects as a primary food source. Shifts in the timing of insects' appearance in the spring can be of great concern for migratory species than travel long distances, as their survival may rely on this food source (Government of Alberta, 2012). By extension, the birds' reproductive success is negatively impacted, as procreative energy expended by many species depends on the availability of food (Winkler, Luo, & Rakhimberdiev, 2013).

The tree swallow is an insectivorous songbird that has been studied at BBO since its establishment in 1984 (Darren McGregor, n.d.). These birds are commonly found in open prairies and wetlands across North America (Cornell University, 2015). Tree swallows are easily recognized, exhibiting iridescent blue plumage and a bright white underbelly (Cornell University, 2015). These aerodynamic birds are highly social, gathering together in large flocks to moult and migrate (Steven, 1980). Defending nests against predators is often a communal operation, and swallows will ward off predators with alarm vocalizations and dive bombing behaviour (Cornell University, 2015).

Tree swallows are recognized for their ability to tolerate a significant amount of nest disturbance without abandoning their chicks (Steven, 1980). These birds exhibit a monogamous breeding system, although occasional polygynous behaviour has also been documented. Breeding pairs typically produce one brood per year, and readily utilize man-made nest boxes (Steven, 1980). Because of these behavioural characteristics, the tree swallow is widely used in avian surveys and biological research (Winkler et al., 2013).

The tree swallow has been used as the object of this study over the years for many reasons, including the ones listed above. We must understand species' breeding biologies and how various factors affect reproductive success in order to determine the sensitivities of certain species to variance in climatic conditions. Once this has been achieved, protective measures may be implemented in an attempt to increase reproductive success and survival rates in migratory bird species.

Methods

Data were gathered in the summer of 2017, from the second week in May to the third week in July. The data used in this study were collected from tree swallow nests residing in some of the 65 nest boxes in the road grid, located along Township Road 510 at the south end of the Beaverhill Natural Area.

The road grid consists of identical wooden nest boxes set on fence posts arranged between 1 and 4 metres apart. The diameter of nest box entry holes was 3.8 cm, wide enough for the entry and exit of adults, but narrow enough to prevent larger predators from entering the boxes. Nest boxes were monitored weekly on weather permitting days. The following box contents were assessed: presence of avian activity, nest state, species present, egg number and temperature, presence or absence of adults, and nestling number and age (see Appendix II for basic breeding parameters). Fledglings were banded upon reaching between ten and twelve days of age, just before departing the nest. Once fledglings had left the nest, boxes were emptied and cleaned in preparation for the following breeding season.

The parameters used to measure nesting success were brood size and number of fledglings. Data from a nest were only used in analysis if there was at least one fledgling that hatched successfully. The average precipitation from 1986 to 2016 in the Tofield area in the months of May, June, and July is 226 mm (The Weather Network, 2017). In 2016, the precipitation between these months equalled a total of 230.3 mm, making it a wet year (see Appendix I). In the following year, the seasonal precipitation was 148.7 mm, making it a dry year (The Weather Network, 2017). The clutch size and number of fledglings (assuming they had successfully left the nest) for the dry year (2017; low seasonal precipitation) and the wet year (2016; excessive rainfall) were compared to determine if the seasonal precipitation affected reproductive success in a positive or negative way. A two-tailed z-test was used to analyze the difference in means for each parameter.

Results

Each data set was analyzed using a two-tailed z-test. There were two null hypotheses in the experiment; represented as H_{o1} and H_{o2} . These hypotheses were as follows: H_{o1} = there is no mean difference between the means of clutch sizes between the years 2016 (wet year) and 2017 (drought year). H_{o2} = there is no mean difference in brood sizes between the years 2016 (wet year) and 2017 (drought year).

Table 1. Two-sample z-test comparing the means of TRES clutch sizes from the 2016 and 2017 breeding seasons.

	2016	2017
Mean	6.02777778	6.15789474
Known Variance	0.999	0.731
Observations	36	38
Hypothesized Mean Difference	0	
z	-0.6002688	
P(Z<=z) one-tail	0.27416355	
z Critical one-tail	1.64485363	
P(Z<=z) two-tail	0.5483271	
z Critical two-tail	1.95996398	

The calculated P value of -0.60 was found to be less than the critical P value of 0.05, so we reject H_{01} . This indicates that there is a significant difference in the means of clutch sizes between the years 2016 and 2017.

Table 2. Two-sample z-test comparing the means of TRES brood sizes from the 2016 and 2017 breeding seasons.

	2016	2017
Mean	5.52777778	5.86842105
Known Variance	1.28	1.04
Observations	36	38
Hypothesized Mean Difference	0	
z	-1.3579749	
P(Z<=z) one-tail	0.08723583	
z Critical one-tail	1.64485363	
P(Z<=z) two-tail	0.17447165	
z Critical two-tail	1.95996398	

The calculated P value of 0.09 was greater than the critical P value of 0.05, so we accept H_{02} . This indicates that there is not a significant difference in the means of brood sizes between the years 2016 and 2017.

Discussion

Through this study, it was found that seasonal precipitation does have a significant effect on the clutch size of tree swallows, but does not affect the brood

size of these birds. The adult swallows exhibited a higher reproductive output in a dry year than a wet year, which disproves the original hypothesis that clutch size would decrease in a year with lower seasonal precipitation. Although food abundance would likely have been greater in the wet year, the larger clutch sizes in the dry year may be explained by an increase in seasonal temperature. Dawson, Lawrie, & O'Brien (2005) found that adults using artificially heated nests produced larger clutch sizes. In 2017 there was not only a lack of seasonal precipitation, but higher temperatures as well. This may have caused increased clutch sizes.

There was no visible difference in fledgling survivorship between 2016, a year with excess rainfall, and 2017, a year where the seasonal precipitation was lower than average. This finding did not align with the original hypothesis that stated fledgling success would increase in a wet year. Lombardo et al. (1995) suggested that the amount of seasonal precipitation had no effect on the parental care of tree swallows, but rather the type and amount of nest lining material used. Adult tree swallows invest large quantities of their energy into collecting specific feathers to insulate their nests. The survival of chicks relies on sufficient nest temperature that is made possible by proper insulation (Lombardo et al., 1995). Increased precipitation had seemingly no effect on the adults' ability to collect the appropriate type and amount of feathers necessary to properly insulate their nests.

There are various factors that influence reproductive success in avian species. Dawson et al. (2005) found that nest temperature can significantly affect the growth and survival rate of fledglings. Alternatively, tree swallow nesting success has been attributed to high food availability (McCarty & Winkler, 1999). In addition, there are confounding variables in the experiment that affected the results of the study, including natural predators and interspecific competition. Because many environmental and behavioural factors affect the birds' reproductive potential, it cannot be concluded that a decrease in seasonal precipitation will definitively increase clutch size in tree swallows.

Weaknesses in the Experimental Design

Throughout the 2017 experimental period, five mouse nests were found in nest boxes, and in 2016, seven were found. The presence of mice deters swallows from using nest boxes, and could have altered the data. A suggestion is to establish protective coverage around the poles nest boxes are attached to in order to decrease stress and harm caused by mice to eggs, fledglings, and adults. In addition, there were different interns collecting the data in 2016 and 2017, which could lead to an inconsistency in data collection and skewed results. In future studies, it is

recommended to have one individual collecting data, in order to limit bias and ensure consistency in data collection.

Conclusion/Implications

Through this study, it has been determined that seasonal precipitation does have a significant affect on the clutch size of tree swallows, but not the brood size. The findings oppose the hypotheses; this implies that there are various aspects that determine success of the birds and survivorship of the young, and that seasonal precipitation is not the dominant factor.

The experimental findings are not sufficient enough to make definite assumptions of the extent of the effects of seasonal precipitation on tree swallow success. Therefore, more research needs to be conducted in order to better understand individual species' requirements when it comes to ideal conditions to generate the greatest reproductive success. Future research may focus on how environmental aspects affect adult swallow breeding behaviour, such as temperature and location of nest boxes. Another potential area of study could be determining the extent to which mice and other competing species deter swallows from nesting. This research project has provided valuable insight into the reproductive behaviours of the tree swallow, and suggestions for future research.

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Appendices

Appendix I

Table 3. Tofield Weather Data.

Time Period	Precipitation from May-June (mm)
Average (1986-2016)	226
2016	230.3
2017	148.7

Appendix II

Table 4. Basic breeding parameters of the tree swallow, nesting in the road grid at BBO for the months of May, June, and July, 2017.

	Range	Average
Date of first egg laid	May 19-June 13	May 26
Clutch size	1-7	5.2
Hatch date	June 8-July 3	June 15
Brood size at hatch	4-7	5.9
Brood size at 7 days	1-7	5.6