Effects of anthropogenic disturbances on the nesting success of Tree Swallows at Beaverhill Natural Area, 2018

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Introduction

Beaverhill Bird Observatory (BBO) is located within the Beaverhill Natural Area, an internationally recognized Important Bird Area for many avian species (Beaverhill Bird Observatory, 2018) that has been monitoring and tracking species for decades. In particular, the monitoring of Tree Swallows, *Tachycineta bicolor*, has been conducted since 1984 (Beaverhill Bird Observatory, 2018). This well-known and easily identified bird is a familiar summer sighting across North America, with their iridescent blue backs, white breast and neck, chirping call, and swift acrobatic flight (Cornell University, 2017).

T. bicolor are often used as environmental quality indicators (Jones, 2003). These swallows are considered secondary cavity nesting species and will often use artificial nest boxes which makes them easily accessible for research purposes (Custer 2011). As an aerial insectivore, *T. bicolor* will often feed in close proximity to their nests (300 to 400m vicinity) on emergent aquatic insects (Custer et al. 2003). Since these birds remain close to their nesting sites even during feeding, they could potentially be impacted by nearby disturbances. Throughout North America, there has been a steep decline in population of various aerial insectivorous birds, likely due to wetland drainage or cropping intensity which can decrease the abundance of insects (Stanton et al. 2016). Human disturbance can have a major impact on the success of bird populations. Polycyclic aromatic hydrocarbons (PAH), which are commonly found in vehicle emissions, can inhibit avian growth when exposed to the eggs or nestlings (Fernie et al. 2018). The quality of the nest box sites, such as food availability, predator density and overall dispersal of the nest boxes, has also been documented to have a possible adverse effect on reproductive success of swallows (Lagrange et al., 2017). Traffic noise has been found to cause altered parental behaviour and reduced nestling body size which can potentially decrease the likelihood of post fledging survival (Injaian et al. 2018). Increased noise has been found to alter the feeding interactions and overall communication between parent and young (Leonard et al. 2015). One of the nest box grids monitored by BBO interns is located alongside a road where traffic noise and pollution from vehicles could possibly hinder the reproductive success of the nest boxes. Two grids were compared to determine if human disturbance would impact nesting success of *T. bicolor*. The contents of nest boxes located north of BBO in an open grassland were monitored and compared to data collected by Bianca Unrau along Rowan's Route (Township Road 510). The spiral grid in the field is hypothesized to have a higher hatch success than the road grid due to less anthropogenic disturbances.

Methods

The contents of the 46 *T. bicolor* nest boxes (nA=35; Fig. 1 and 4) on the spiral grid were recorded weekly from May to August (a total of 12 weeks data). The spiral grid was located north of BBO in a relatively open grassland with some shrubbery on the forest edge. Boxes are located at varying distances from each other in a "spiral" like fashion. Outfitted on metal posts for protection from ground predators, the boxes are consistent in size and structure, and emptied of previous nest materials in the spring.

The contents of the 66 *T. bicolor* nest boxes (nB=44; Fig. 1 and 4) on the road grid were checked weekly as well, from May to August (a total of 11 weeks data). The road grid is located south west of BBO outside the natural area on fence posts alongside the gravel road leading to the Beaverhill Natural Area entrance. Again, the boxes were consistent in structure and size, and emptied of nesting materials in the spring.

The contents of nest boxes were examined for species type (Tree Swallows-TRES, House Wren-HOWR and Mountain Bluebird-MOBL), nest activity (inactive or active- lined, partial and full nest), clutch size and temperature (warm or cold), presence of adults (absent, remained or present- remained in vicinity or flushed from nest), nestling number, nestling age (aged 1-12+ days using an aging guide provided by BBO) and comments and observations on the nest box. Box number, nestling number and nestling age was shared with the BBO biologists for banding purposes throughout the data collection period. To compare significance, a two tailed t-test for independent samples was conducted with the spiral and road grid clutch sizes and repeated with their fledgling success.

Results

Of the 46 spiral grid nest boxes, 35 were inhabited by TRES (Fig.1 and 4), 8 by HOWR, 1 by MOBL and 2 unoccupied. Figure 1 and 4 show that during the breeding season, there was a total of 202 TRES eggs laid and 176 successful fledglings.

Of the 66 road grid nest boxes, 44 were inhabited by TRES (Fig.1 and 4), 1 by HOWR, 3 by MOBL and 18 unoccupied. There was a total of 249 TRES eggs laid and 162 successful fledglings in this grid (Figure 1 and 4).

The mean clutch size was 5.77 eggs for the spiral grid and 5.66 eggs for the road grid (Fig. 1). The average fledgling success for the spiral grid was 5.03 fledglings/box and 3.68 fledglings/box for the road grid (Fig. 4). The variances between the two grids are equal when using a p value of >0.05 (Fig. 3 and 6). The clutch size between the spiral grid and the road grid do not differ significantly (t_{77}=0.38, p=0.70; Fig. 2). The fledgling success between the spiral grid and the road grid are significantly different (t_{77}=2.63, p=0.01; Fig. 5).

Data Summary

	A	B	Total
n	35	44	79
ΣX	202	249	451
ΣX^2	1216	1493	2709
SS	50.1714	83.8864	134.3038
mean	5.7714	5.6591	5.7089

Figure 1. Data summary for clutch sizes, A is the spiral grid and B is the road grid.

$Mean_a - Mean_b$	t	df			
0.1123	+0.38	77	P	one-tailed	0.352496
				two-tailed	0.704992

Figure 2. Results for clutch size comparison.

df_1	df_2	F	P
43	34	1.33	0.196540

Figure 3. F-test for the significance of the difference between the variances of the two samples clutch sizes.

Data Summary			
	A	B	Total
n	35	44	79
ΣX	176	162	338
ΣX^2	1010	864	1874
SS	124.9714	267.5455	427.8734
mean	5.0286	3.6818	4.2785

Figure 4. Data summary for fledgling success, A is the spiral grid and B is the road grid.

$Mean_a - Mean_b$	t	df	P		
1.3468	+2.63	77		one-tailed	0.0051535
				two-tailed	0.010307

Figure 5. Results for fledgling success comparison.

df_1	df_2	F	P
43	34	1.7	0.056348

Figure 6. F-test for the significance of the difference between the variances of the two samples fledgling success.

Discussion

The data analysis of the clutch size revealed there was no significant difference between the spiral grid and the road grid. However, the analysis determined that there was a significant difference between grids in regard to fledging success. There are a few possibilities as to why the nest boxes in the spiral grid were more successful than the road grid. As previously mentioned, those boxes located in close proximity to a road or any human disturbance has been found to negatively impact the overall success of *T. bicolor* reproduction. Exposure of birds to PAHs from vehicles has been found to cause mortality or reduced growth (Fernie et al. 2018). While a small number of the nest boxes in the spiral grid are located a few meters from a volunteer parking lot, the area is rarely exposed to vehicles in comparison to the road grid. Rowan's Route is used significantly more, with each nest box within two meters of the road. Traffic noises caused by vehicles has been found to increase oxidative stress in nestlings and reduced growth (Injaian et al. 2018). Reduced growth has been found to cause a delay in when fledglings leave the nest, increasing the risk of predation (Stakeet al. 2005). Human produced noise exposure has also been linked to fledging delay (Injaian et al. 2018). This may explain why some of the nest boxes on the road grid remained occupied long after all the boxes from the spiral grid were abandoned. The delay caused by noise exposure or reduced growth can be detrimental as predation on nests is higher in the final days of the fledgling period (Stake et al. 2005).

The quality of the sites may have also impacted the differences in reproductive success. The spiral grid was located in a more natural area, with more abundant vegetation and less human disturbance. This may have affected the availability of food as there was likely a higher abundance of insects in the less disturbed site. Agricultural intensification and other human disturbance has been linked to the decline of invertebrates used by many bird species as food sources (Paquette et al. 2013). The spiral grid also contained more shrubs and trees which may have acted as protection for the nest boxes from predators. The road grid nest boxes were attached to a fence that ran along the road. There was no shrubbery or trees that could have acted as cover for the nest boxes. The nest boxes being in a more open area may explain why the road grid nests were predated on more heavily than the nests located in the spiral grid. The distribution of nest boxes may have been a factor in predation. Tree swallows have been found to join other swallows in defending nests from predators, through passive defense by circling above the predator (Winkler 1994). The spiral grid contained boxes that were closely distributed to one another, while the road grid has each box placed in a line. Having nest boxes close to one another may have acted as better defense from predators, as neighboring birds could aid through passive defense. Overall, we found that, while clutch size was unaffected, the success of the nest boxes located in the spiral grid was significantly higher when compared to the nests located on the road grid. Future studies can be conducted to further examine the effects on reproductive success of *T. bicolor*, to best determine the cause of the differences for these particular sites.

Conclusion

Studying the effects of anthropogenic disturbances on *T. bicolor* can assist in understanding how further human expansion and area use will affect environmental quality and thus, biodiversity and wildlife reproductive success. Tree swallows are a model species for contamination in avian populations (Custer 2011). Using *T. bicolor* as a bioindicator for pollution levels by studying their behaviour, physiology and reproductive success due to human induced disturbances, long term impact studies can reveal thresholds for avian success living amongst human activity (Injaian et al. 2018). On a global scale, avian population declines will have significant ecosystem repercussions because of their numerous roles played in ecosystem processes (Şekercioğlu et al. 2004). This decline can negatively affect human health and existence, and further deteriorate the quality of the environment. Being able to monitor hatch success in Tree swallows under the disturbance of humans will allow science to not only find thresholds of disturbance, but also pinpoint significant factors creating these negative impacts leading to detrimental outcomes and assist in finding solutions to mitigate and reduce our impacts on these populations.

To improve the study and enhance future findings, treatments manipulating noise and air pollution around *T. bicolor* nest boxes can be used to identify a threshold of disturbance that negatively affects hatch success. Creating more treatments with varying disturbances will also give a larger sample size to analyze. Controlling other factors and influences such as food availability, habitat, predator density, and nest box density as suggested by Lagrange et al. (2017), will help isolate the effects of human disturbances and minimize the influence of other factors on hatch success. Understanding human impacts on nesting success will assist in providing solutions to declining avian populations to help preserve biodiversity.

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