Impacts of agriculture on the average clutch size and nest box occupancy of *Tachycineta bicolor* within the Beaverhill Natural Area

Abstract:

In an attempt to strengthen the previously hypothesized relationship between agricultural development and declining aerial insectivore populations, the average clutch size and nest box occupancy of *Tachycineta bicolor* were examined within the Beaverhill Natural Area. A reduction in an important *Tachycineta sp.* food source, dipterans, caused by agricultural development was posited to vary based on proximity of nest box grids to agricultural development, impacting clutch size and occupancy values. Nest box data was collected from the three grids weekly or bi-weekly and was analyzed using ANOVA tests. No significant difference was found between the grids' average clutch sizes; however, the proportion of nest box vacancies was found to be significantly higher in the grid nearest to the agricultural development. This observed nest box vacancy association concurs with previous findings and reiterates the necessity of further investigation into minimizing the impacts of agriculture on aerial insectivores.

Introduction:

As illustrated by Jones (2003), *Tachycineta bicolor* – commonly known as the tree swallow- is both an environmental quality indicator as well as a frequent subject within the study of avian behaviour; however, the population of North American aerial insectivores such as tree swallows has been declining at a rate which surpasses that of other passerines (Nebel, Mills, McCracken, & Taylor, 2010). As presented by Hussell and Quinney, variable insect availability is an influential factor with regards to the mean clutch size of *Tachycineta* sp. (1985). Processes such as agricultural development, which have been linked to lower dipteran abundances (Paquette, Garant, Pelletier & Bélisle, 2013), are a potential threat to the tree swallow population as dipterans comprise a large proportion of their diet (Quinney & Ankney, 1985). As well as impacts to average clutch size, decreasing nest box occupancy by tree swallows has also been a consequence of increases in surrounding agricultural development (Ghilain & Bélisle, 2008).

The *Tachycineta* sp. nest box grids at the Beaverhill Natural Area are located at varying proximities to an actively planted/harvested field. Within the context of this paper proximity to agricultural development and the assumed subsequent changes in insect availability will be treated as the key differences between nest box grids. For the purposes of this study, “agricultural development” will refer to land which has been modified in order to allow for efficient agricultural production and which is actively planted and harvested for a crop. Whether proximity to agriculturally developed land ultimately impacts the average clutch size and proportion of occupied nest boxes by *Tachycineta* sp. at the three grids is addressed. Because the “R” grid is attached to fence posts along the harvested field, one can hypothesize that it will exhibit the lowest average clutch size and the largest percentage of unoccupied nest boxes due to a reduction in dipteran abundance. The “S” grid is furthest from the developed field, and therefore, it is hypothesized that it will have the highest clutch size and the lowest percentage of unoccupied nest boxes as it will have the highest dipteran abundance. The “T” grid, located at an intermediate distance between the R and S grids, is hypothesized to have the intermediate values for average clutch size and proportion of unoccupied nest boxes, due to an intermediate availability of dipterans.

Materials and Methods:

Nest box data was collected from three different sites in the region of the Beaverhill Natural Area, located outside of Tofield, Alberta. Data was gathered from the point of nest formation to the fledging of chicks, on a weekly or bi-weekly basis from the 50 boxes in the S grid, 65 boxes in the R grid, and 48 boxes in the T grid. The relevant data consists of the number of eggs present in each nest box. The distance from each grid to the nearest instance of agricultural development was assessed based on informal visual survey. In the case of inconsistencies in final recorded clutch sizes, eg. fluctuating numbers between weeks, the highest number was used to calculate the average for each grid.

In order to analyze clutch size, data from 32 S grid boxes, 37 T grid boxes, and 29 R grid boxes was evaluated with an ANOVA test. Nest boxes containing no nests and/or no eggs were excluded from the analysis, as were nests belonging to species other than *Tachycineta bicolor.* In order to compare the number of unoccupied nest boxes between grids, an ANOVA test was also used, using all 50 of the boxes from grid S, 43 of the nest boxes from grid T and 63 of the boxes from the R grid – omitting boxes containing other species, but recording boxes with partial or full nests containing no eggs as occupied.

Results:

The S grid was found to have the highest average clutch size of 6.28, the T grid was found to have an average clutch size of 6.27, and the R grid was found to have the lowest average clutch size of 6.17; however, no significant difference was detected between the three sites ($F_{2, 95}$ = 0.0999, p=0.905). Approximately 14% of both the grid S nest boxes and the grid T nest boxes were found to be unoccupied by *Tachycineta sp.*, while grid R exhibited the highest degree of vacancy ($\bar{X} = 0.365$) (Figure 1). The differing proportion of unoccupied nest boxes was shown to be significant ($F_{2, 153} = 5.66$, $p<0.01$).

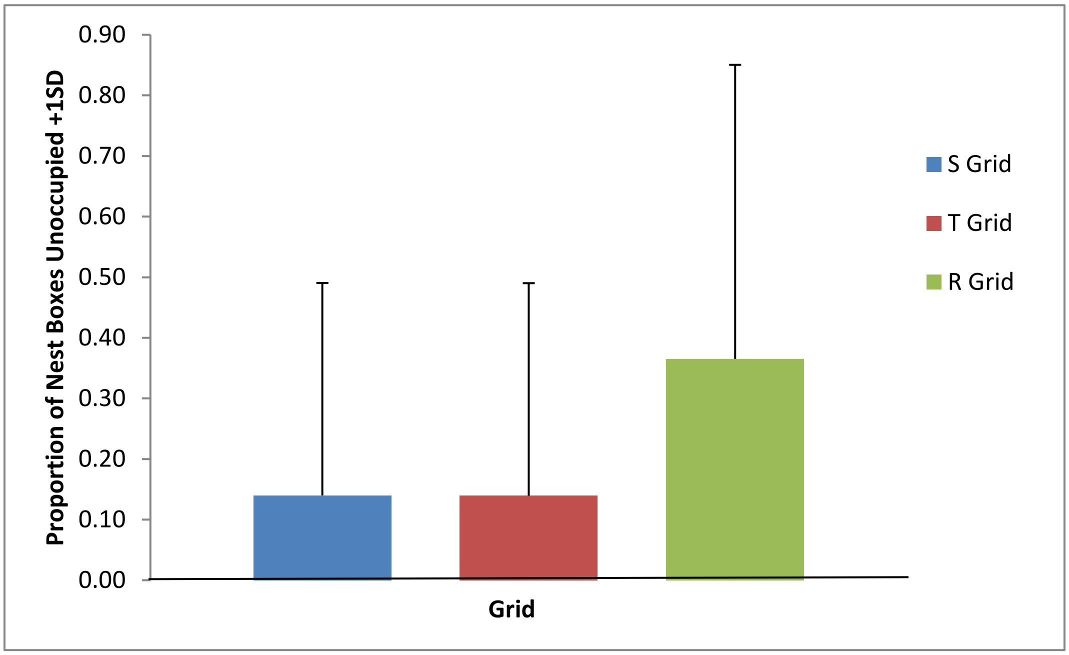

Figure 1. Proportion of nest boxes unoccupied by *Tachycineta bicolour* at three grid locations.

Discussion:

Contrary to the original hypothesis, no significant difference in average clutch size was observed between the three grids. Although the mean clutch size for grid S is higher than that of grid T, which is higher than grid R, as predicted, the differences appear quite minor and have high probability of occurrence due to chance. The previously cited study by Paquette et al., which assisted in the formation of the original hypothesis, found dipteran abundance to decrease with agricultural intensification (2013); however, they also observed some instances of increases in dipteran abundance with agricultural development, illustrating the potential for cases which do not concur with the generalization. It was also found that the variation in dipteran abundance became intensified as the season progressed (Paquette et al., 2013). This seasonal variation, in concert with the finding that average clutch size is most impacted by insect abundance during the laying period (Hussell et al., 1985), may explain the similar average clutch sizes between grids. Ultimately, dipteran abundance reduction may not have coincided with the critical egg-laying period, resulting in clutch sizes that do not reflect the agricultural impact. As well, the hypothesis that dipteran abundance declines with proximity to agriculture is based on factors such as the use of pesticides and the homogenization of the surrounding landscape (Paquette et al., 2013). The degree to which these aforementioned factors are present in the developed field within our study are unknown, and may also account for the lack of significant difference.

As hypothesized, the R grid was found to have the highest percentage of unoccupied nest boxes, supporting the conclusion that agricultural development may play a role in the decline of aerial insectivore populations; however, the percentages of vacancy within the T and S grids were within 0.05% of one another (the T grid being the lower number). This finding disagrees with the original hypothesis that the S grid would have the smallest percentage of unoccupied nest boxes. The assumption that dipteran abundance would increase with distance from the developed field may have been invalid, accounting for the disparity. It is possible that after a certain distance from the agricultural development, dipteran abundance is no longer impacted regardless of the distancing after that point.

Although the relationships between agricultural development, insect abundance, and tree swallow clutch size / nest box occupancy have been investigated within various studies, this particular study acts to further examine these conclusions. This study lacks exact metrics of all variables (eg. insect abundance); however, it does act as a potential starting point for future, in depth study within the Beaverhill Natural Area region. As suggested by Ghilain et al., evidence of damage to aerial insectivore population resulting from agricultural development, merits examination into potential solutions such as alterations to pesticide use and harvesting practices. (2008).

Appendix

Table 1. Grid S nest box clutch size values and overall clutch size average.

Box Number	Clutch Size
2	7
3	8
4	7
5	7
6	5
8	8
10	7
12	6
14	6
15	6
16	4
17	6
18	7
20	6
21	6
23	7
24	6
25	7
27	7
28	5
30	3
32	7
37	6
38	6
39	6
41	7
43	7
44	5
45	7
46	5
48	7
50	7
$\bar{X}$	6.28

Table 2. Grid T nest box clutch size values and overall clutch size average.

Box Number	Clutch Size
1	8
2	7
3	7
5	7
6	7
7	6
8	6
9	7
10	6
12	7
13	6
15	6
16	7
18	7
19	6
21	6
22	7
23	6
24	7
25	6
26	5
27	7
28	6
30	8
31	1
32	6
34	6
35	7
36	5
37	5
38	7
39	7
40	7
41	6
42	5
45	7
48	5
$\bar{X}$	6.27

Table 3. Grid R nest box clutch size values and overall clutch size average.

Box Number	Clutch Size
1X	6
2	7
3	6
5X	5
6	6
7	6
9	7
10	4
10X	6
12	7
13X	7
15	5
19	7
20	6
22	6
23	6
24	6
25	6
26	7
27	7
28X	6
32	7
35	6
37	6
38	5
39	6
43	6
44	7
46	7
$\bar{X}$	6.17

Table 4. ANOVA output for average clutch between Grids S,T,and R.

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.218471	2	0.109235	0.099874	0.905046	3.092217
Within Groups	103.904	95	1.093726			
Total	104.1224	97				

Table 5. Grid S nest box occupancy and overall proportion of nest boxes unoccupied, where 0 represents occupied and 1 represents unoccupied.

Box Number	Unoccupied Nest Box ?
1	0
2	0
3	0
4	0
5	0
6	0
7	1
8	0
9	0
10	0
11	0
12	0
13	0
14	0
15	0
16	0
17	0
18	0
19	1
20	0
21	0
22	1
23	0
24	0
25	0
26	1
27	0
28	0
29	1
30	0
31	1
32	0
33	0
34	0
35	0
36	0
37	0
38	0
39	0
40	0
41	0
42	0
43	0
44	0
45	0
46	0
47	1
48	0
49	0
50	0
$\bar{X}$	0.140

Table 6. Grid T nest box occupancy and overall proportion of nest boxes unoccupied, where 0 represents occupied and 1 represents unoccupied.

Box Number	Unoccupied Nest Box ?
1	0
2	0
3	0
4	1
5	0
6	0
7	0
8	0
9	0
10	0
11	1
12	0
13	0
14	1
15	0
16	0
18	0
19	0
20	1
21	0
22	0
23	0
24	0
25	0
26	0
27	0
28	0
29	1
30	0
31	0
32	0
34	0
35	0
36	0
37	0
38	0
39	0
40	0
41	0
42	0
45	0
46	1
48	0
$\overline{X}$	0.140

Table 7. Grid R nest box occupancy and overall proportion of nest boxes unoccupied, where 0 represents occupied and 1 represents unoccupied.

Box Number	Unoccupied Nest Box ?
1	1
1X	0
2	0
2X	1
3	0
3X	1
4	0
4X	0
5	0
5X	0
6	0
6X	1
7	0
7X	1
8	1
8X	1
9	0
9X	1
10	0
10X	0
11	1
11X	1
12	0
12X	1
13	1
13X	0
14	1
14X	0
15	0
15X	1
16	1
16X	1
17	0
18	1
19	0
20	0
21	0
22	0
23	0
24	0
25	0
26	0
27	0
28	1
28X	0
29	0
30	1
31	0
32	0
33	0
34	0
35	0
36	1
37	0
38	0
39	0
40	1
41	1
42	1
43	0
44	0
45	0
46	0
$\bar{X}$	0.365

Table 8. ANOVA output for proportion of unoccupied nest boxes in Grids S,T,and R.

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1.906342391	2	0.953171196	5.655603397	0.004269	3.055162
Within Groups	25.7859653	153	0.168535721			
Total	27.69230769	155				

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