Occupancy of three bat house sizes across different habitats at the Beaverhill Bird Observatory

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Introduction

Bats, order Chiroptera, are the most diverse group of mammals with over 1400 currently extant species (MacSwiney et al. 2008). Bats occupy nearly all terrestrial and habitat zones on Earth and display high diversity in both food types and roost use (Schnitzler and Kalko 2001). Bats that are frugivorous, nectarivorous, and insectivorous are especially important to natural ecosystems globally. Nectarivorous bats pollinate over 500 species of flowering plants worldwide, including the plant *Agave tequiliana*, the source of commercial tequila (Kunz et al. 2011). Frugivorous bats aids in seed dispersal, and thus can influence plant diversity in forests. Insectivorous bats are of utmost importance to humans in that they eat insects, including agricultural pest species such as cucumber beetles and stink bugs in the southern United States (Kunz et al. 2011). The agricultural benefits of insectivorous bat activity have been measured in numerous studies, and it has been discovered that bats cats can consume up to 25% of their body mass in insects in a single night (Kunz et al. 2011). In addition, lactating *Myotis lucifugus* can consume over 100% of their body mass in a single night (Kunz et al. 2011). Studies in the tropics have found an increase in insect density and leaf damage by over 65% when bats are excluded, and estimates show that the loss of bats in North America could lead to a loss of more than $3 billion yearly in the agricultural sector (Boyles et al. 2011; Kunz et al. 2011). In Alberta, Canada, all nine bat species present are insectivorous (Vonhof and Hobson 2001), with six of these species found in the Beaverhill Natural Area. The presence of bats worldwide combined with their rich diversity has even lead to the consideration of bats as a possible biodiversity indicator species in assessing responses to climate change (MacSwiney et al. 2008). Unfortunately, despite these benefits, bats are currently subject to several risks worldwide.

Firstly, bats are currently under risk of mass habitat loss and destruction due to climate change and anthropogenic activities such as logging and agriculture (Dillingham et al. 2003; Mering and Chambers 2014). Second, bats are also at risk from the increasing use of wind turbines, with 11 of 45 known North American bat species being identified as wind turbine casualties (Kunz et al. 2007; Frick et al. 2017). North American migratory bats are especially at risk, with 75% of casualties identified as *Lasiurus cinereus*, *Lasiurus borealis*, and *Lasionycteris noctivagans*, all migratory bats, and the majority of casualties from August through November, during fall migration (Kunz et al. 2007; Frick et al. 2017). The current greatest threat to North American bats, however, is White-Nose Syndrome (WNS), an infectious disease caused by the fungus *Pseudogymnoascus destructans* that appears as a white growth across the bat's wings and muzzle (Frick et al. 2015; Olson et al. 2011). *P. destructans* is a fungus that thrives during cooler temperatures and is transmitted via bodily contact, which contributes to WNS being associated with winter hibernation and the close proximity of bats in their hibernacula (Frick et al. 2016).

WNS is transmitted during the fall while bats return to their hibernacula, with infection peaking during winter months (Invasive Species Compendium [accessed 2019]). WNS is present in various European and Asian countries but did not appear in North America until 2006, when it was discovered in a single cave in New York (Invasive Species Compendium [accessed 2019]). Today, WNS is estimated to have killed over 5 million bats in eastern North America and is spreading west (Frick et al. 2016). Currently, 31 US states and 5 Canadian provinces have bats showing symptoms of WNS, with WNS stretching as far west as Manitoba and Washington state (Invasive Species Compendium [accessed 2019]). WNS affects bats during the winter months when bats enter long states of torpor, or periods when metabolic rate and body temperature are decreased significantly (Reeder et al. 2012). Bats do not remain in torpor throughout the entirety of winter, however, as torpor is broken up by brief periods of arousal where metabolic rates and body temperatures increase (Reeder et al. 2012). These arousal periods account for only 1% of the time during winter but use up to 90% of the bat's available energy (Reeder et al. 2012). Bats prepare for these arousal periods and for the lack of food availability during winter by building up fat stores throughout the summer months (Reeder et al.

2012). However, in bats infected with WNS, these arousal periods happen more frequently resulting in the infected bat using up its entire energy store before spring and dying as a result (Frick et al. 2016). Bat populations also have difficulty in recovering from WNS due to most bat species giving birth to only a single pup per year (Frick et al. 2017). Three species of bats in Canada were listed as endangered in 2015 from the effects of WNS, with two of these species (*Myotis lucifugus* and *Myotis septentrionalis*) being found in Alberta (Frick et al. 2016). Although bats display numerous benefits to natural ecosystems and to human economies, there is currently a lack of long-term bat monitoring programs and standard survey protocols worldwide. With the current threat of WNS to North American bat populations, clearly, there is a need for standardized monitoring programs to be deployed to gather data of bat populations for future conservation efforts (Olson et al. 2011). One method of both monitoring bat populations and accounting for the loss of habitat and natural roosts is through the use of artificial roosts, such as bat houses.

Bats are estimated to spend over 50% of their lives roosting, as roosts provide protection from weather and predators, provide hibernation areas, provide lower commuting times between foraging sites, and provide a location for reproductive purposes (Mering and Chambers 2014). Typically, old-growth forests show the greatest densities of bats due to the high amount of roosts available, but habitat loss from forestry and other human activities are leading to a loss of these roosts (Mering and Chambers 2014). Habitat fragmentation is also of concern, as this leads to longer distances to cover between roosting sites, resulting in greater energy expenditures to the bats (Mering and Chambers 2014). One way to mitigate the loss of roosting sites is by placing artificial sites such as bat houses in areas used by bats. Typically these bat houses are designed to mimic natural roosting sites by providing different sizes and numbers of crevices (Dillingham et al. 2003). One of the difficulties associated with bat houses is that it is not currently known exactly what characteristics of roosts are favoured by bats and what influences whether bats will choose or avoid a bat house (Mering and Chambers 2014). Not all bat species roost in artificial roosts either, such as *L. cinereus* and *L. borealis*, two bat species found in Alberta that are solely tree-roosters (Klug et al. 2011; Vonhof and Hobson 2001). Bats have been found to forage as close as within 15 metres from their chosen roosting site (White 2004), and so placing roosts in locations with low risks to the bats is essential. It has also been shown that bats may use more than one roost during a season thus showing the need for multiple-roost availability (Ball 2002; Mering and Chambers 2014; White 2004).

In this study, we gathered data on bat roosting behaviour at the Beaverhill Bird Observatory (BBO)using bat house occupancy numbers. Although we were unable to identify the bat species occupying the houses, we would expect to see *M. lucifugus*, *M septentrionalis*, and *E. fuscus* species using the bat houses, and possibly *L. noctivagans* as well. The purpose of this study is to further establish monitoring of BBO's bat population by collecting and comparing occupancy data to previous years of study in this area. Bat occupancy numbers were compared over different bat house designs and habitat types to identify trends or preferences in bat house designs or habitat type.

Methods

Study Area

This study was conducted at the Beaverhill Bird Observatory (BBO) located near Tofield in the dry mixed-wood natural sub-region of Alberta. The BBO is located in a predominantly forested area with mature aspen forest, grassland, wetland, stream, and lake features. There are 35 bat houses being monitored weekly. The bat houses are located across four different habitat types; clearing, interior, open and edge. Most bat houses are easily accessed by or near a trail (Figure 1). The natural area is only accessible by foot; ATVs and vehicles are not permitted within the BBO for conservation purposes. Two houses were not included for the majority of the study due to beaver activity and an active wasp nest, while a third house was temporarily lost due to beaver activity (Appendix 4).

Figure 1. Map of the Beaverhill Bird Observatory bat house and habitat distribution in Tofield, Alberta.

Bat House Distribution

The bat houses within the BBO are located across four different habitat types: clearing (Figure 2a), interior (Figure 2b), edge (Figure 2c) and open (Figure 2d). The clearing habitat type consists of an open area with slightly-dense surrounding areas but have minimal tree coverage (i.e. if the house was located in a significant open area that was surrounded by forest on all sides). Open habitat consists of an open grass field with minimal shrub and no tree cover. The interior habitat is dominated by dense tree coverage (i.e. bat house within the forest). The edge habitat is located along Flicker Freeway with surrounding ponds and or water.

There are three distinct bat houses across the BBO; large brown, medium green and small red bat houses (Figure 3). The large brown bat house has two types: a newly single-chambered house and a multi-chamber house (Figure 3ai; Figure 3aii).

Potential confounding variables were recorded weekly including maximum daily temperature, percent humidity, wind speed, and moon illumination (Appendix 2). Temperature data were obtained from the weather station at Elk Island National Park, Alberta. The BBO is about 43 km southeast of Elk Island National Park and therefore assumed to be affected by similar weather conditions and temperature patterns.

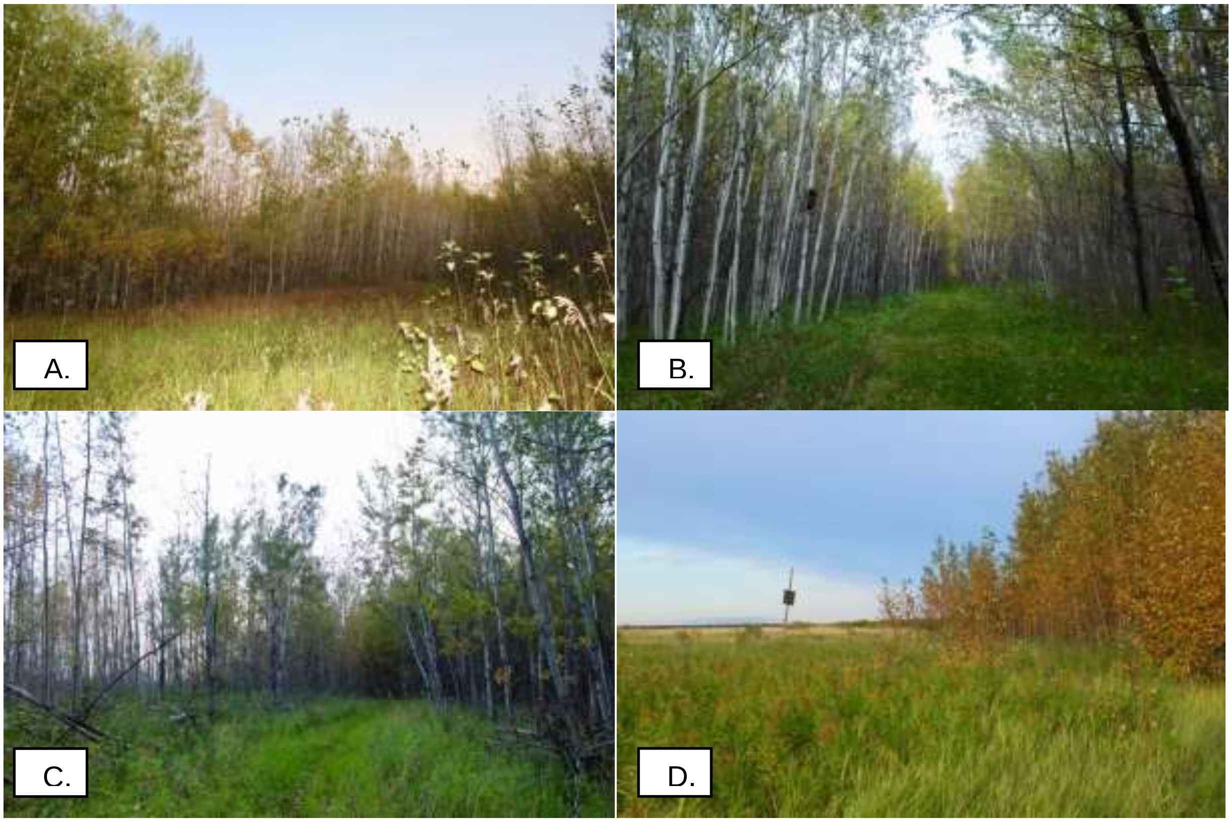

Figure 2. Four different habitat types across the Beaverhill Bird Observatory – clearing (a), interior (b), edge (c) and open (d) habitat types.

Figure 3. Three different types of bat house according to colour and size – large brown single-chambered (ai.), large brown multi-chambered (aii), medium green (b), small red (c).

Bat House Occupancy Monitoring

Over the course of twenty weeks, a total of 35 bat houses of three different colours and three sizes were monitored for occupancy from May 17 to September 28, 2019. During each survey period, a data-sheet was filled which included information such as date, start and end times, presence of rain and moon, and sunset time (Appendix 1). Bat occupancy surveys began an hour and a half before sunset time to count bat occupancies in each house before emergence times at sunset. Bat house occupancy was determined by briefly shining a light into the bottoms/entry-way of bat houses, and the number of individual bats was counted. A weekly survey involved walking across a number of trails and designated routes to each house. The flashlight was shone at an angle so the top corners of the interior of the bat house could be seen (Figure 3). The bats were counted and reported in each corresponding datasheet. However, it was often challenging to determine the exact number of bats count as they were in close proximity to each other, and therefore an estimated range was reported.

Figure 3. Method of shining the flashlight into the interior of the bat house.

Results

Overall, 24 out of the total 35 bat houses were occupied at some point during the study, meaning 68.6% of bat houses were occupied. Out of the houses that were occupied, three were only occupied once (houses 30, 21, and 8) and 21 were occupied more than once. This means that over the course of twenty weeks, 12.5% of the occupied bat houses were occupied only once and 87.5% of the occupied houses were occupied more than once.

Over the course of twenty weeks, a total of 230 occupancies were recorded, with four of these occupancies found within the BBO building on August 30, 2019 and September 14, 2019. These four occupancies were not included in statistical testing. Ninety-nine more occupancies were recorded compared to last year's data (Caron and Hlewka 2018) and 124 more occupancies compared to 2017 (Low 2017). Out of the 24 occupied bat houses, 15 were also occupied in previous years (Low 2017) (Figure 4), meaning that nine bat houses were occupied for the first time. Six new large brown multi-chambered bat houses were also studied for the first time this year, and five of these six new houses were occupied at some point during the summer (Figure 4).

Bat House 14 had the greatest overall occupancy out of all the bat houses (Figure 4; Appendix 6). The most consistently occupied houses were 14, 6, 11, 12, 2, 3, 7, 15, and 37, with each of these houses being occupied on at least 6 dates (Figure 6). We found that the peaks of bat house occupancies were in June and July (Figures 4 and 5). The highest numbers of occupancies in relation to bat house size occurred within large brown houses (161 bats), in comparison to 37 bats for medium green and 32 for small red houses (Figure 4). Only large size bat houses were occupied during all five months of the study, while small and medium houses were occupied only from May to August (Figure 4). Furthermore, the highest numbers of occupancies in relation to habitat type occurred within clearing (126 bats), in comparison to 69 bats for interior, 22 bats for edge and 13 bats for open habitats (Figure 5). The open habitat type was only occupied from July to September, while edge habitat type was only occupied from June to August (Figure 5). Clearing habitat was occupied during all months of sampling, while interior habitat was occupied from May to August (Figure 5).

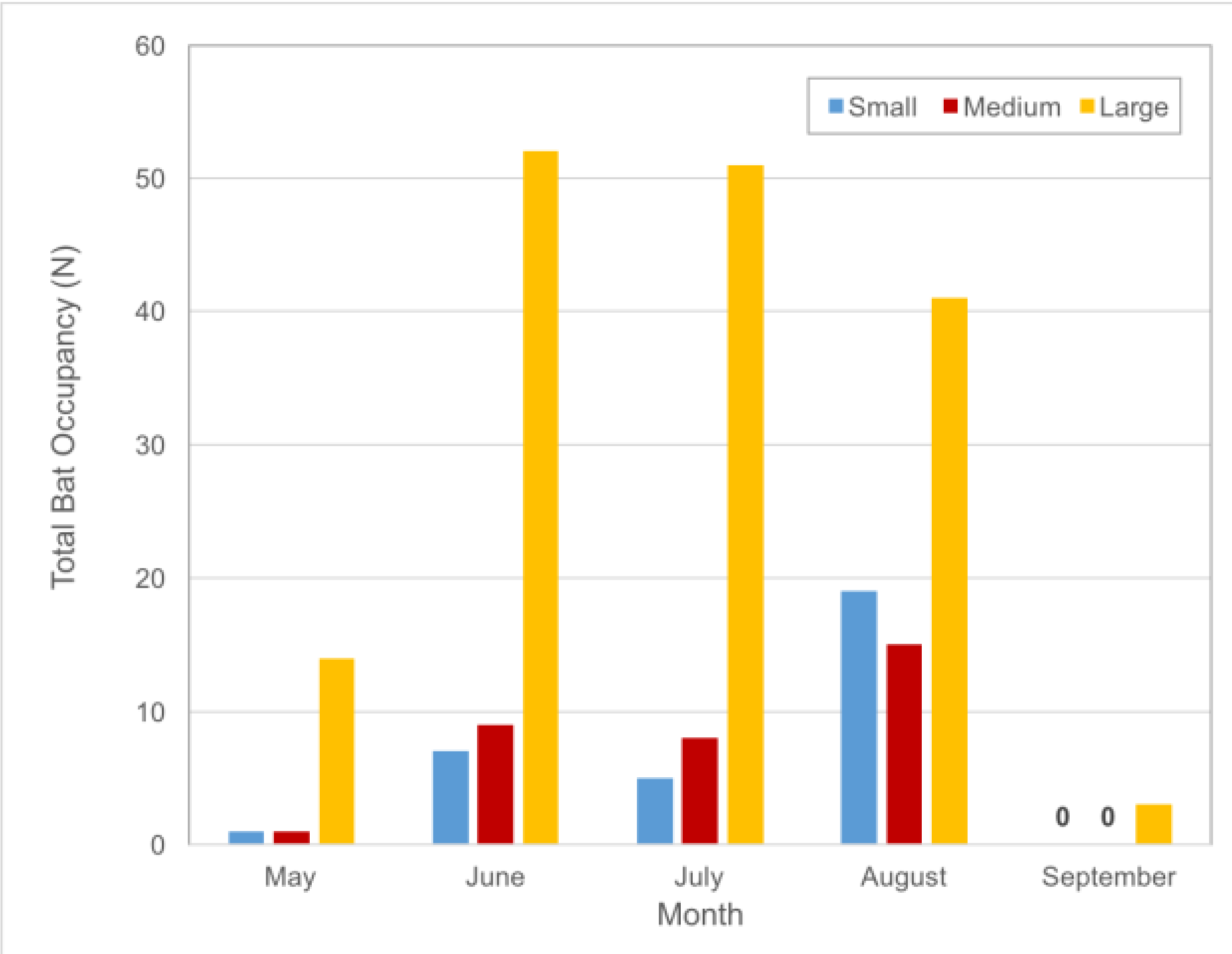

Figure 4. Total number of bat house occupancies (N = individuals) across different sizes of bat houses (Small, Medium and Large) over the course of five months (May, June, July, August and September).

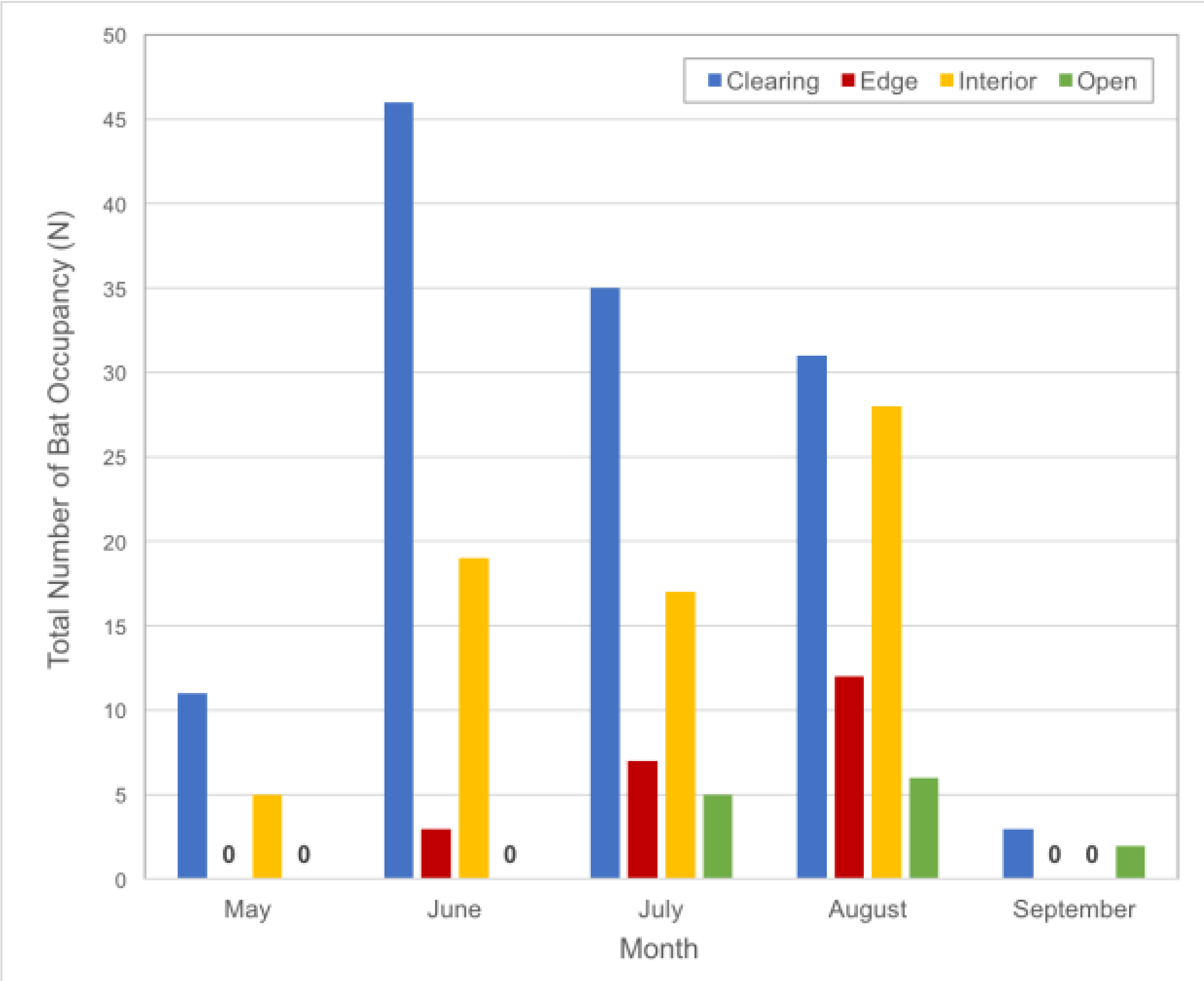

Figure 5. Total number of bat house occupancies (N = individuals) across different habitat types (Clearing, Edge, Interior and Open) over the course of five months (May, June, July, August and September).

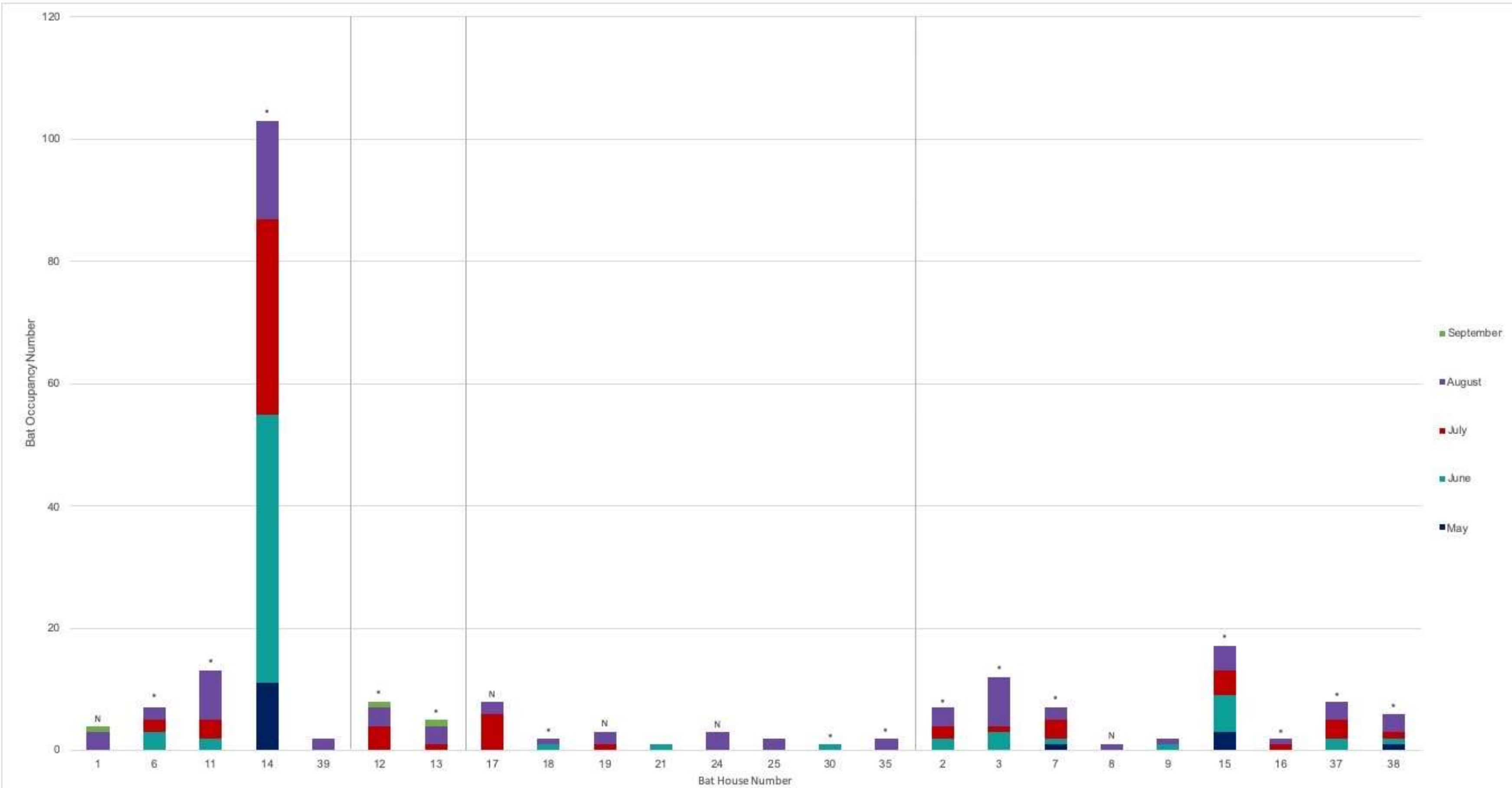

Figure 6. Total bat occupancy in each bat house occupied over the course of five months (May, June, July, August, and September). Plotted data (*) indicates which bat houses have been occupied in previous years (Low 2017). N indicates houses that were not present at the BBO until this year. These houses are large brown multi-chambered houses.

Boxplot analyses of bat house occupancy show that there is a significant difference between large bat houses in comparison to small and medium bat houses (Figure 7). We also found that there is a significant difference in bat occupancy in clearing habitat in comparison to other habitat types - interior, open and edge (Figure 8). The results suggest that bats had a significant preference for large brown bat houses, and habitats in the clearing, while the edge was the least favoured habitat.

To further analyze the findings, we ran post-hoc tests where the family-wise corrector for alpha used was the Bonferroni's corrector ($p=0.05$). A significant difference was found between large and medium bat houses ($p=0.003$), and large and small houses ($p=<0.001$). No significant difference was found between medium and small bat houses ($p=0.84$). Furthermore, there are significant differences between clearing and edge habitats ($p=<0.001$), clearing and interior ($p<0.001$) and for clearing and open ($p=0.002$). There were no significant differences ($p=1.00$) between edge and interior habitats, edge and open, and interior and open.

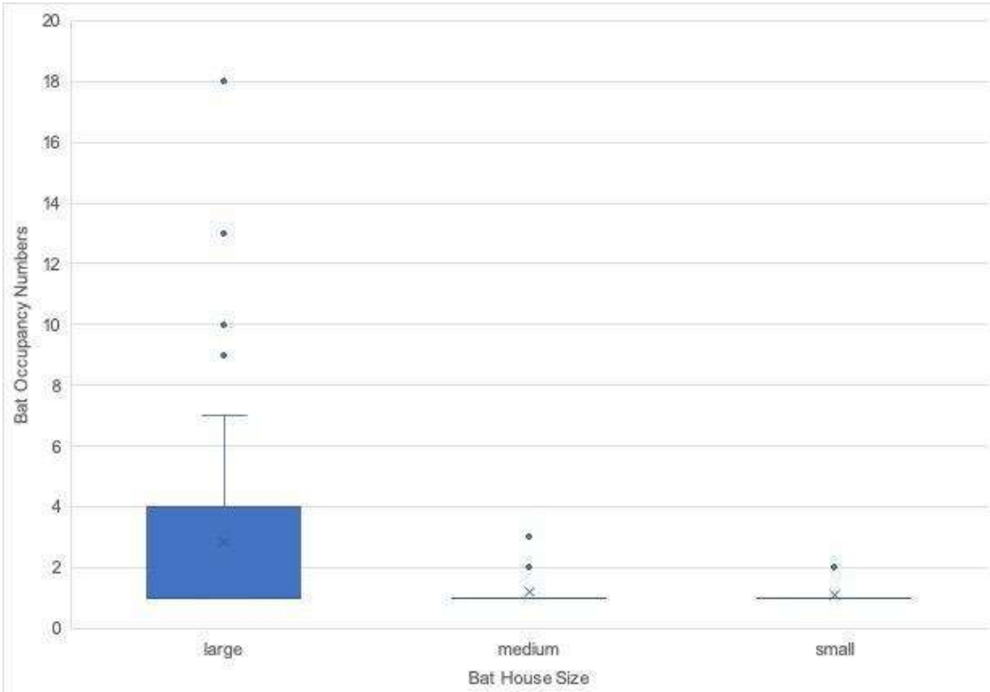

Figure 7. Total bat occupancy (± SD) per bat house sizes (Small, Medium and Large) during the course of five months - May, June, July, August and September 2019. X indicates mean. Dots above the error bars indicate potential outliers.

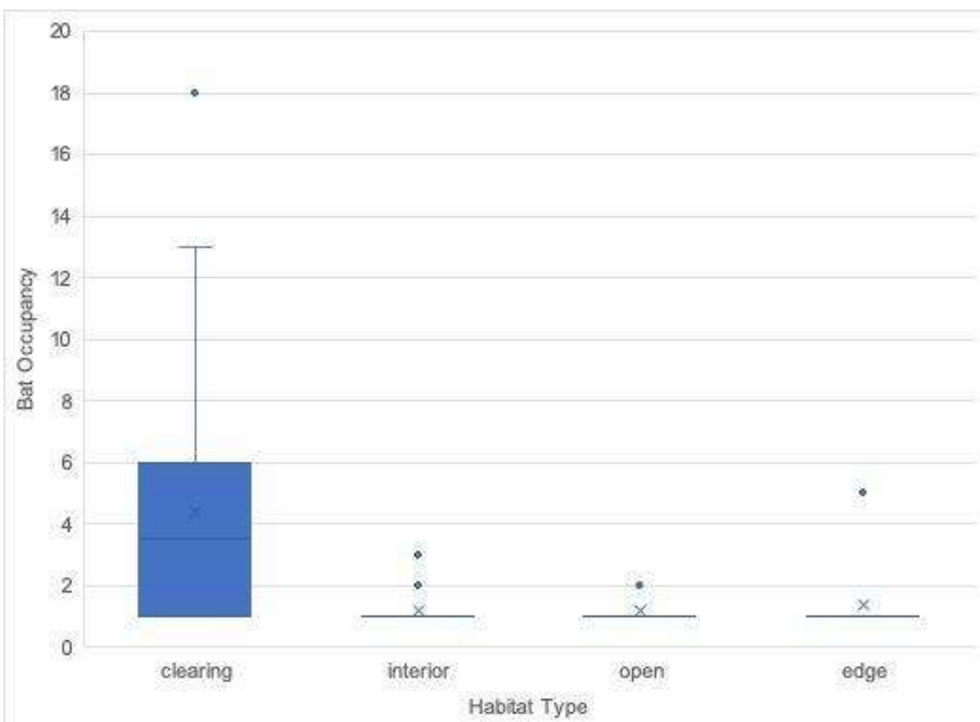

Figure 8. Total bat occupancy (± SD) by habitat types (Clearing, Interior, Edge and Open) during the course of five months - May, June, July, August and September 2019. X indicates mean.

To determine if there was a correlation between confounding variables and occupancy rates, the number of bats observed was plotted against each of the following variables; max daily temperature (˚C), percent humidity, percent moon illumination and wind speed. Overall, all factors show minimal to no correlation between occupancy rates. The variations in bat house occupancy determined by R^2 values are explained by the following; 13.3% for percent humidity (Figure 9a), 0.43% for wind speed (Figure 9b), 1.51% for percent moon illumination (Figure 9c) and 1.64% for daily maximum temperatures (Figure 9d).

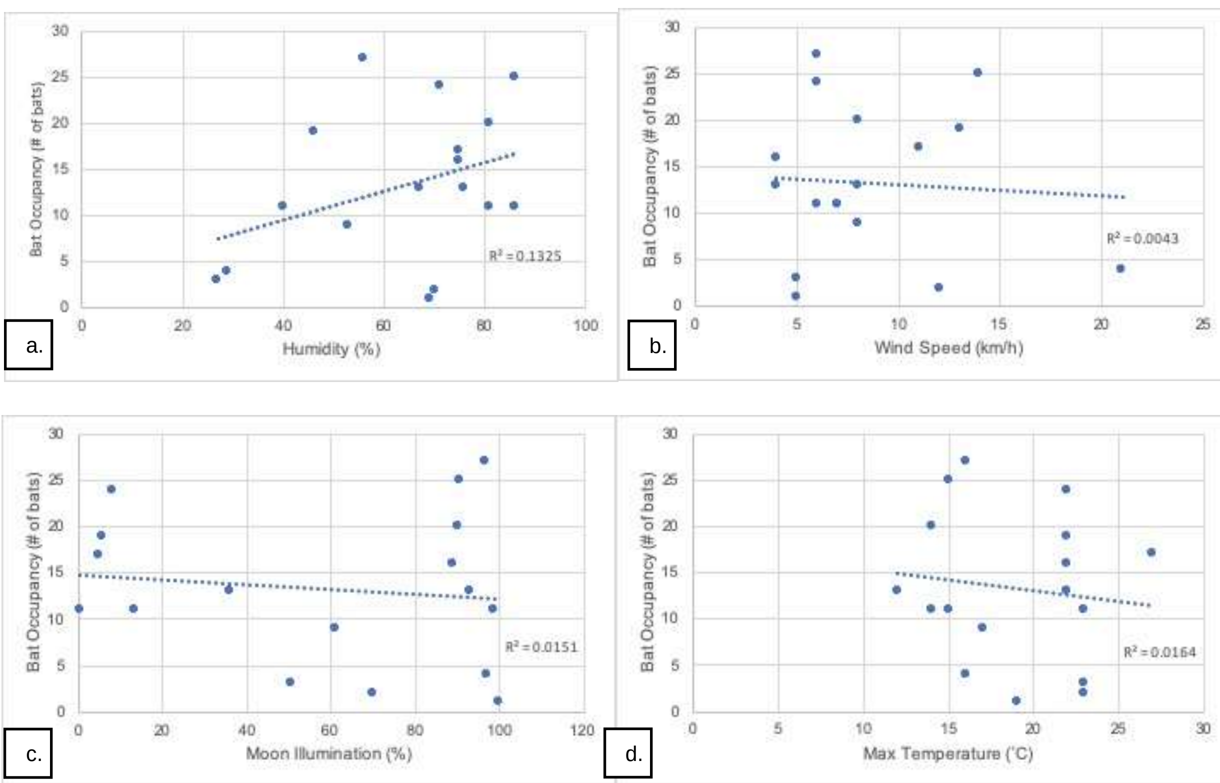

Figure 9. Number of bats observed occupying bat houses plotted against percent humidity (a), wind speed (b), percent moon illumination (c) and maximum daily temperatures (d) from May 11 to September 21, 2019. R^2 indicates percent variability of total bat activity (in terms of house occupancy) that is explained by x-axis variables.

Rain occurred during seven out of the 17 weeks that bat house occupancy surveys were conducted, but did not occur during the dates with the greatest or lowest number of occupancies (Figure 10). The moon was present during 10 of the 17 sampling periods when bat house occupancy surveys were conducted but were not present during the 3 highest or lowest occupancy dates (Figure 10).

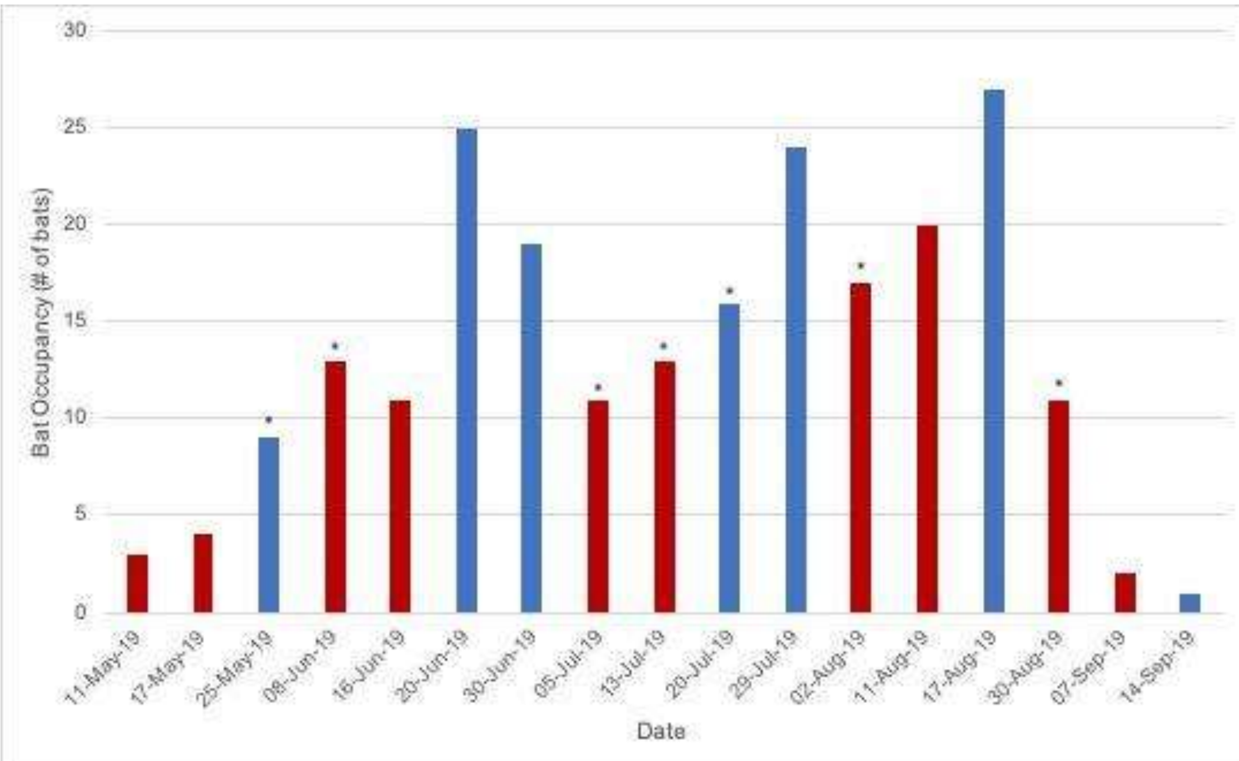

Figure 10. Total bat occupancy with respect to presence of moon and rain during each sampling night. Red columns indicate the moon is present during sampling period, blue columns indicate absence of moon during sampling periods. * indicates rain occurred during the sampling date.

Discussion

Overall, it appears that bats preferred large-sized houses and clearing habitats for roosting. These results differ from previous years in that we added a third category for bat house sizes and a fourth category for habitat types. However, we believe our results show that this change is significant and that to continue with the two house sizes and three habitat types as previous years would risk diluting the data.

With regards to bats preferring larger sized bat houses, this agrees with results in other literature, where it was also found that bats typically preferred larger houses with multiple chambers within these houses (Dillingham et al. 2003). However, it has also been found that bats may change roosts for a variety of reasons (Ball 2002; Mering and Chambers 2014), and we did find that bats were occupying the medium- and small-sized houses in similar numbers. Therefore, we would recommend that bat houses installed at the BBO should primarily be large houses, with a smaller number of medium and small houses available as well. We also found that five of the six new large brown multi-chambered houses were used this year. Typically these houses were not used as much as older houses and usually had five or fewer bats occupying them at a time, but this could change throughout the next few years as bats start to return to these houses. We saw that house number 14 showed an increase of almost 100 bats this summer when compared to last year (Caron and Hlewka 2018), and thus we would expect a greater number of bats to begin using the new large brown multi-chambered roosting-style houses next summer.

With respect to habitat types, typically bats tend to prefer roosts located in less-cluttered environments such as forest edges and fields than highly-cluttered forest environments that would interfere with echolocation (White 2004), which agrees with our results. However, other studies have shown that bats prefer roosts located near water (Bayne 2012), which in the BBO's case would typically be edge-habitat houses, which our results did not agree with. This could possibly be due to the fact that the edge-habitat houses, while located near to water, were still located in a forest environment, and thus the preference for proximity to water may not have had as much of an effect as the issue of clutter from surrounding trees would.

Our results also showed a peak in bat house occupancy in the months of June and July. From the perspective of a bat yearly calendar, it is expected to see the largest numbers in the months of June and July and lower numbers in August and September due to the fall migrations (Kunz et al. 2007; Bayne 2012). The fact that open habitat houses were not occupied until July and were the only habitat type occupied in the final week where bats were present at the BBO may be a result of the change in bat behaviour due to migration during the fall months. The fact that 87.5% of occupied bat houses were occupied more than once suggests that bats may have been occupying these houses consistently, while the 12.5% of bat houses that were only occupied once were only occupied transiently. Houses 14, 6, 11, 12, 2, 3, 7, 15, and 37 were all occupied on six or more dates during the sampling period, and so were the most consistently occupied houses, while houses 14, 15, 3, and 11 had the greatest occupancy in terms of total numbers of bats. Houses 2, 3, 6, and 7 are medium houses, while houses 11, 12, 14, and 15 are all large houses, and 37 is a small house (Appendix 3). When looking at total occupancy numbers, three of the four houses are large houses, again suggesting that large houses will be occupied the most, but bats do require a number of different types of houses to be available. Five of the consistently occupied houses were located in interior habitats, while four of these houses were in clearing habitats and one was in open (Appendix 3). For the top occupancy houses, two were in clearing and two in interior habitats. Again, considering that three different habitat types are present in terms of the most occupied houses suggests that having a large variety of house types and habitat types available to the bats to roost in is essential.

Though the results of this study are clear and significant, one cannot deny that there are limitations of the study. One of the limitations is that there are a few factors as to why bats were never observed roosting in particular houses. Factors such as large hornet nests, blockage of bat house entry-way by cobwebs or leaves and poor location of bat houses in areas that would be hard for bats to navigate through may all contribute to why some houses remained unoccupied throughout the study. We would recommend for future studies about occupancy at the BBO to include frequently cleaning the interior of bat houses and to place more large-sized houses, especially in clearing environments. We would also recommend looking further into the clearing habitat type, as our results show a significant difference between clearing and all other habitat types.

Conclusion

Our findings suggest that the bats found in the Beaverhill Bird Observatory prefer clearing habitat types and large brown bat houses. Future studies could involve longer-term monitoring programs, and involve a greater number of bat houses, especially those of larger sizes and in clearing habitats.

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Appendix

Appendix 1. Sample data sheet.

Bat Monitor Recording Data Sheet, Beaverhill Bird Observatory – Bat Houses and Acoustics 2019

Sunset Time: _________ **Monitoring Start Time:** __________ **Recording date:** ________________________
Rain during night (n/y; time): ___________ **Echolocation Start Time:** _________ **Moon visibility (time interval):** ____________
Observer: ___________________________

Bat House Monitoring				Bioacoustics			
Bat House #	Had Bats?	# of Bats	Notes	Bat House #	Acoustics Detected?	Species	Notes

Appendix 2. Summary of confounding variables.

	May 11	May 17	May 25	June 01	June 08	June 16	June 20	June 30	July 05	July 13	July 20	July 29	Aug 2	Aug 11	Aug 17	Aug 30	Sept 07	Sept 14	Sept 21	Sept 28
Precipitation (mm)	0	0	1.2	0	2.3	0	0	0	2.5	0.6	0.6	0	1.2	0	0	2.3	0	0	0	0
High ˚C	23	16	17	26	12	23	15	22	15	22	22	22	27	14	16	14	23	19	22	3
Low ˚C	18	11	10	18	6	16	12	18	14	16	14	15	18	14	12	10	15	12	13	2
Wind (km/h)	5	21	8	12	8	7	14	13	7	5	4	6	11	8	6	6	12	5	7	7
Wind Direction	E	SE	SSW	E	WNW	S	NNE	SSW	ESE	W	E	SSE	SE	SW	N	E	S	S	NW	ENE
Sunset	21:17	21:27	21:39	21:48	21:55	22:01	22:02	22:02	21:59	21:53	21:44	21:31	21:24	21:06	20:54	20:24	20:05	19:48	19:31	19:14
Moon Presence (A)	Y	Y	N	N	Y	Y	N	N	Y	Y	N	N	Y	Y	N	N	Y	Y	N	N
Moon Presence (O)	Y	Y	N	N	Y	Y	N	N	Y	Y	N	N	Y	Y	N	Y	Y	N	N	Y
% Illumination	50.5	96.6	60.9	3.4	36.2	98.7	90.8	5.6	13.5	92.9	88.8	8.1	4.7	90.1	96.8	0.4	69.9	99.8	56.2	0.2
Humidity (%)	27	29	53	46	67	40	86	46	81	76	75	71	75	81	56	86	70	69	61	67

Appendix 3. Raw data of bat house occupancy.

Date	Bat House Number	Habitat Type	Bat House Colour	Bat House Size	N
11-May-19	14	clearing	brown	large	2
11-May-19	15	interior	brown	large	1
17-May-19	14	clearing	brown	large	4
25-May-19	14	clearing	brown	large	5
25-May-19	15	interior	brown	large	2
25-May-19	7	interior	green	medium	1
25-May-19	38	interior	red	small	1
08-Jun-19	14	clearing	brown	large	7
08-Jun-19	30	edge	red	small	1
08-Jun-19	15	interior	brown	large	2
08-Jun-19	7	interior	green	medium	1
08-Jun-19	9	interior	red	small	1
08-Jun-19	38	interior	red	small	1
16-Jun-19	11	clearing	brown	large	1
16-Jun-19	14	clearing	brown	large	6
16-Jun-19	15	interior	brown	large	1
16-Jun-19	2	interior	green	medium	1
16-Jun-19	3	interior	green	medium	1
16-Jun-19	6	interior	green	medium	1
20-Jun-19	14	clearing	brown	large	18
20-Jun-19	18	edge	red	small	1
20-Jun-19	21	edge	red	small	1
20-Jun-19	15	interior	brown	large	2
20-Jun-19	3	interior	green	medium	1
20-Jun-19	6	interior	green	medium	1
20-Jun-19	37	interior	red	small	1
30-Jun-19	11	clearing	brown	large	1
30-Jun-19	14	clearing	brown	large	13
30-Jun-19	15	interior	brown	large	1
30-Jun-19	2	interior	green	medium	1
30-Jun-19	3	interior	green	medium	1
30-Jun-19	6	interior	green	medium	1
30-Jun-19	37	interior	red	small	1
05-Jul-19	11	clearing	brown	large	1
05-Jul-19	14	clearing	brown	large	7
05-Jul-19	15	interior	brown	large	1

05-Jul-19	37	interior	red	small	1
05-Jul-19	12	open	brown	large	1
13-Jul-19	14	clearing	brown	large	6
13-Jul-19	17	edge	brown	large	1
13-Jul-19	15	interior	brown	large	1
13-Jul-19	16	interior	brown	large	1
13-Jul-19	7	interior	green	medium	1
13-Jul-19	37	interior	red	small	1
13-Jul-19	12	open	brown	large	2
20-Jul-19	14	clearing	brown	large	9
20-Jul-19	19	edge	red	small	1
20-Jul-19	15	interior	brown	large	1
20-Jul-19	2	interior	green	medium	1
20-Jul-19	6	interior	green	medium	1
20-Jul-19	7	interior	green	medium	1
20-Jul-19	37	interior	red	small	1
20-Jul-19	38	interior	red	small	1
29-Jul-19	11	clearing	brown	large	2
29-Jul-19	14	clearing	brown	large	10
29-Jul-19	17	edge	brown	large	5
29-Jul-19	15	interior	brown	large	1
29-Jul-19	2	interior	green	medium	1
29-Jul-19	3	interior	green	medium	1
29-Jul-19	6	interior	green	medium	1
29-Jul-19	7	interior	green	medium	1
29-Jul-19	12	open	brown	large	1
29-Jul-19	13	open	brown	large	1
02-Aug-19	1	clearing	brown	large	1
02-Aug-19	11	clearing	brown	large	1
02-Aug-19	14	clearing	brown	large	5
02-Aug-19	17	edge	brown	large	2
02-Aug-19	19	edge	red	small	1
02-Aug-19	15	interior	brown	large	1
02-Aug-19	16	interior	brown	large	1
02-Aug-19	2	interior	green	medium	1
02-Aug-19	3	interior	green	medium	1
02-Aug-19	7	interior	green	medium	1
02-Aug-19	9	interior	red	small	1
02-Aug-19	37	interior	red	small	1

11-Aug-19	11	clearing	brown	large	4
11-Aug-19	14	clearing	brown	large	4
11-Aug-19	19	edge	red	small	1
11-Aug-19	24	edge	red	small	1
11-Aug-19	35	edge	red	small	1
11-Aug-19	15	interior	brown	large	1
11-Aug-19	3	interior	green	medium	2
11-Aug-19	6	interior	green	medium	1
11-Aug-19	37	interior	red	small	1
11-Aug-19	38	interior	red	small	1
11-Aug-19	12	open	brown	large	1
11-Aug-19	13	open	brown	large	2
17-Aug-19	1	clearing	brown	large	1
17-Aug-19	11	clearing	brown	large	3
17-Aug-19	14	clearing	brown	large	5
17-Aug-19	39	clearing	red	small	1
17-Aug-19	18	edge	red	small	1
17-Aug-19	24	edge	red	small	2
17-Aug-19	25	edge	red	small	1
17-Aug-19	35	edge	red	small	1
17-Aug-19	8	interior	brown	large	1
17-Aug-19	15	interior	brown	large	1
17-Aug-19	2	interior	green	medium	2
17-Aug-19	3	interior	green	medium	2
17-Aug-19	6	interior	green	medium	1
17-Aug-19	7	interior	green	medium	1
17-Aug-19	37	interior	red	small	1
17-Aug-19	38	interior	red	small	2
17-Aug-19	12	open	brown	large	1
30-Aug-19	1	clearing	brown	large	1
30-Aug-19	14	clearing	brown	large	2
30-Aug-19	BBO	clearing	N/A	N/A	2
30-Aug-19	39	clearing	red	small	1
30-Aug-19	1	clearing	brown	large	1
30-Aug-19	14	clearing	brown	large	2
30-Aug-19	39	clearing	red	small	1
30-Aug-19	BBO	clearing	N/A	N/A	2
30-Aug-19	25	edge	red	small	1
30-Aug-19	15	interior	brown	large	1

30-Aug-19	3	interior	green	medium	3
30-Aug-19	12	open	brown	large	1
30-Aug-19	13	open	brown	large	1
30-Aug-19	3	clearing	green	medium	3
30-Aug-19	12	open	brown	large	1
30-Aug-19	13	open	brown	large	1
30-Aug-19	15	interior	brown	large	1
30-Aug-19	25	edge	red	small	1
07-Sep-19	1	clearing	brown	large	1
07-Sep-19	12	open	brown	large	1
14-Sep-19	BBO	clearing	N/A	N/A	2
14-Sep-19	13	open	brown	large	1
21-Sep-19	N/A	N/A	N/A	N/A	0
28-Sep-19	N/A	N/A	N/A	N/A	0

Appendix 4. Photos of a bat house taken down by the beavers.

Appendix 5. Photos of bats found residing in the Beaverhill Bird Observatory building.

Appendix 6. Photos of bats seen residing in Bat House Number 14 on June 08, 2019 (left) and June 20, 2019 (right).