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BI 402 Independent Study

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Introduction

Background

Bird window-strikes are one of the most significant causes of bird mortality. Using the approximation that one building results in approximately 1-10 avian deaths per year, a speculative estimate of bird mortality in the United States predicts anywhere from 100 million - 1 billion avian deaths annually due to bird-window collisions (Klem 2006). In Toronto, a study estimating Canadian avian mortality suggested 24.9 million deaths per year due to collisions with tall buildings alone (Machtans et al. 2013). Though these collisions impact mortality in many bird species, only about 25% of bird species in Canada and the United States and 6% of birds worldwide are impacted by window-strike fatalities (Klem 2006). These species of birds are those found to inhabit areas near human development. Though there are many other causes of avian mortality, such as collisions with wind turbines, and predation by cats, collision with a building is by far the leading cause of bird mortality (Erickson 2005). Historically, these collisions were often thought to only be an issue with tall buildings, but more recent research has found that window-strike fatalities are an issue with all buildings, including residential homes (Bracey et al. 2016, Machtans et al. 2013). There are many factors that are thought to contribute to window-strike fatalities for birds, including species-specific effects, environmental effects and factors associated with the building itself.

Species-Specific Effects

In multiple studies, specific species of birds were often found more commonly as the victims of window-strike collisions. In a Canadian study, warblers and sparrows were found to be the most common victims at both low rise and tall buildings (Machtans et al. 2013). Warblers and sparrows, along with thrushes were found to be the most common families of birds affected by window-strikes in a Manhattan study (Gelb and Delcretaz 2009). A separate study at Augustana College in Sioux Falls, SD identified White-throated Sparrow, Ovenbird, American Robin, Swainson's thrush, Dark-eyed Junco, Ruby-throated Hummingbird, and Northern Cardinal as the most common victims of window-strike fatalities (Hager et al. 2008). It is clear that there is some sort of species interaction that is a factor in window-strike fatalities.

All of the birds mentioned in these studies are members of the Passeriformes order of birds, which are the perching birds, with the main families being thrushes (Tudidae), wood-warblers (Parulidae) and American sparrows (Emberizidae). Thrushes are medium sized birds that inhabit woodlands, swamps, suburbs and parks. Their diet mostly consists of insects, worms and fruit and they forage for food on the ground or glean in low-foliage. Some thrushes are migratory, while others live year round in North America. Wood-warblers are small insectivores that inhabit only the New World, originating from Central America. American sparrows are a group of small birds that feed on seeds and are most prevalent in North America. These three families of birds all inhabit similar environments and have similar diets which may suggest a relatively close evolutionary relation (Encyclopedia of Life).

In addition to specific species being more common victims of window-strike fatalities, some species of birds were more common based on the environment at which the window-strike occurred. For example, in a study done in Toronto, it was found that victims of collisions in urban areas with lots of greenery tended to be foliage gleaners, whereas victims of collisions with urban buildings surrounded by less greenery and more urbanization tended to be ground foragers (Cusa et al. 2015). These correlations are perhaps indicative of the differences in the bird populations in these two environments.

Environmental Effects

Aside from species-specific effects on window-strike fatalities, there are several environmental factors that may affect the rates of window-strike fatalities. One such environmental factor is the presence and placement of bird feeders. It has been found that within a 1m-10m range, bird feeders placed farther away from windows result in greater rates of window-strike fatalities (Klem et al. 2004). This is due to the flight speed that the bird can attain after leaving the bird feeder—the farther away from the window, the more speed the bird will have when it collides with the window, which is more likely to cause a fatality. Bird feeders placed approximately 0.3m from a window are ideal, as the bird cannot gain very much speed after leaving the feeder, and therefore would not hit the window with such force that would cause a fatality (Klem et al. 2004).

Other important environmental factors are seasonal impacts—specifically, the time of year can greatly impact the bird window-strike fatality rate. A study conducted on a university campus in Cleveland, Ohio, found that there were significantly higher rates of bird window-strike fatalities during the spring and fall, likely due to the migration of birds during this time (Borden et al. 2010). With more birds flying through a certain area, there will likely be more collisions. The same logic applies to the density of the bird population, which is also thought to be a factor in bird window-strikes (Cusa et al. 2015, Hager et al. 2008). With more birds, there is a higher chance for a window-strike to occur.

Time of day can also affect collision rates. Though the vast majority of window-strikes occur during the daytime (Klem 2009, Gelb and Delcretaz 2009), nighttime window-strikes are often caused by lights being left on in buildings, creating a “beacon effect” (Drewitt and Langston 2008, Longcore et al. 2012). The lights left on in buildings often act as an attractant to birds flying at night. This can cause more frequent collisions compared to a building with no lights on at night. The lights therefore act as a “beacon” drawing them towards the building and increasing the chance they are involved in a fatal collision.

One of the most important environmental factors that impact window-strike frequencies is the presence and distribution of vegetation. The distance of vegetation from buildings has been found to play a role in the frequency of window-strikes (Klem 2009, Borden et al. 2010). Often, the closer the vegetation is to the building, the more likely a collision will occur. Height of vegetation can also influence the frequency of such collisions, with more collisions occurring at buildings surrounded by taller vegetation (Klem 2009). Finally, the amount of vegetation reflected in the windows of the buildings is thought to be a major factor in determining the rates of window-strikes and fatalities, with a greater percentage of vegetation reflected in the window panes resulting in greater collision frequencies (Klem 2009, Gelb and Delcretaz 2009, Borden et al. 2010). Evidently, the presence of vegetation in close proximity with windowed buildings greatly increases the probability for a window-strike fatality.

Stuctural Effects

In addition to species-specific and environmental effects, there has also been considerable interest in the effects of the physical aspects of the buildings with frequent window-strikes. One such aspect that has been examined for its impact on window-strike fatalities is window size or area of the glass. Such studies have found only minor correlations between an increase in window area and an increase in collision frequencies (Borden et al. 2010, Hager et al. 2008, Klem 2009). A more significant factor is the relative area of windows in comparison to the rest of the façade of a building. Several studies have found a positive correlation between relative window area and the frequency of window-strike fatalities (Borden et al. 2010, Gelb and Delacretaz 2009, Klem 2009). Other factors that have been investigated include window transparency, and distance between buildings (Klem 2009). Transparency of windows has had inconclusive results as to whether or not it makes an impact in window-strike frequency, while a smaller distance between buildings can increase the frequency of window-strikes (Klem 2009). In addition, building location (urban vs. commercial vs. residential) has also been an influential factor, with high rates of window-strikes further from city centers and the highest rates in residential areas (Bracey et al. 2016, Machtans et al. 2013).

With window-strikes being the most significant cause of avian mortality in developed areas, it is important to understand the factors influencing these collisions. Some families within the Passeriformes order have been seen to be more predisposed to window-strikes, mainly those from the American sparrows, wood-warblers and thrushes. Since most of these birds are migratory birds, it is also significant to note that window-strikes are more common during migratory seasons. Characteristics of the vegetation that the birds may shelter in have also been seen to significantly impact window-strike rates. Additionally, building with a larger relative percentage of glass often have higher window-strike rates. In order to help prevent window-strikes, the most significant factors impacting window-strike rates must be determined, and steps need to be taken to minimize the potential for window-strikes.

In this study, building characteristics were examined to determine any patterns of buildings with frequent window-strike collisions. The characteristics examined were building height, size and area of windows, relative percentage of glass of each façade, the presence of paned or un-paned windows, and the direction the façade faced. This characterization of buildings on the Butler University campus will give a foundational understanding of what makes each building similar or different with regards to structural features. In the future, this study is hoped to provide information than can be used to correlate window-strike fatalities to structural features of the buildings.

Methods

Buildings Characterized

The buildings that were characterized in this study were mostly academic buildings on Butler University's campus, with the addition of the Health and Recreation Center (HRC). The academic buildings characterized included Gallahue Hall, Holcolmb Building, Pharmacy Building, and Fairbanks Center, as well as the skywalks which connect Jordan Hall to Gallahue Hall, Gallahue Hall to Holcomb Building and Holcomb Building to Pharmacy Building. For the purposes of this study, Jordan Hall was not characterized.

Characteristics Analyzed

For each façade of every building studied, the height of the building was measured and recorded, the size and area of windows were measured, the relative percentage of glass was calculated, the average aspect ratio of the windows was determined, and the direction the façade faced was recorded.

Character Analysis

Elevation schematics in the form of PDF documents for each building were obtained through the Butler University Operations Department and the Director of Engineering & Administration. Using the "measure" tool on Adobe Acrobat Reader DC and the scale of the drawings provided, the height of the building, total surface area of the façade, and size and area of the windows were measured. From these measurements, the relative percentage of glass and average aspect ratios were calculated.

Plotting Window-strike Fatality Data

Once each building was characterized, window-strike fatalities were plotted on a diagram of the buildings to determine the frequency of fatalities at each façade of the buildings. The data used was collected over the 2015 fall and 2016 spring migratory seasons and obtained through the Center for Urban Ecology (CUE) at Butler University.

Results

Relative Percentage of Glass (Table 1)

Most facades of the buildings and bridges characterized did not have more than 25% glass coverage. Fairbanks was an exception, with every façade having more than 30% glass and two facades with more than 80% glass coverage. The bridges also had a higher relative percentage of glass per façade with 37.5% of each façade being glass. Other facades with greater than 25% window coverage included the south and west facades of Gallahue, the north façade of Holcomb, and the north and south facades of the HRC.

Total Window Area (Table 2)

Most building facades had no more than 3000 sq. ft. of window, again with the exception of Fairbanks, which has two facades with more than 4000 sq. ft. of window coverage. Most buildings had two facades with relatively higher total window area as compared to the other two facades. The bridges had an unusually low total window area compared to the buildings.

Building Height

Most of the buildings are 48 ft. at their tallest point, with an exception of the HRC, which has two facades that are 35 ft. tall and two facades that are 42 ft. tall. The bridges are also an exception, with the top of the bridge 25.667 ft. off the ground, and the bottom of the bridge being 10.833 ft. off the ground.

Average Aspect Ratio (Table 4)

The average aspect ratio for the majority of the buildings indicated that the majority of windows on each façade were taller than they were wide, with exceptions on the north face of Holcomb, the west face of Pharmacy and the north, south and west faces of the HRC. There is also an extreme example of tall vertical windows on the north, east and west faces of Fairbanks and the north and south faces of pharmacy.

Bird Survey Data (Table 5)

The majority of fatalities were seen at Gallahue, Holcomb and the bridges, with the highest frequency of collisions occurring at the west face of Gallahue, the north face of Holcomb and the east face of the Jordan-Gallahue Bridge. More than 1 fatality has been observed at the north and south faces of the two other bridges as well. No fatalities have been observed at Pharmacy, and no data has been collected yet on the HRC or Fairbanks.

Discussion

Though not much data has been collected on window-strike fatalities yet, the facades of the buildings and bridges with the highest window-strike fatality rates all have greater than 25% window coverage (Table 1, Table 5), consistent with previous findings that window-strike fatalities positively correlate with relative percentage of glass on a façade (Borden et al. 2010, Gelb and Delacretaz 2009, Klem 2009). Since this early data suggests a higher relative percentage of glass may contribute to window-strike fatalities, it may be expected to find significant fatalities at Fairbanks and the north and south faces of the HRC. Additionally, the south face of Gallahue and the bridges have windows on the opposite face that allow the other side to be seen through the window, which may contribute to a higher frequency of window-strike fatalities if this transparency decreases the birds' ability to recognize that glass is present. More window-strike fatalities are seen on the north and west facades of the buildings and bridges overall (Table 5), which may be more indicative of the fact that these facades face vegetation more directly than the south and east facades. The amount of and distance to vegetation was not measured for in this study, but has been seen in the past to have a significant impact on window-strike fatality rates (Klem 2009, Gelb and Delcretaz 2009, Borden et al. 2010). This aspect of vegetation and its impact on window-strike fatalities could be investigated further in a future study.

Other future avenues of study for this project include gathering more bird window-strike fatality data in order to determine significant correlations between building characteristics and window-strike fatality frequencies. Once the building characteristics that are most significant in causing window-strike fatalities are known, this can be used to predict where birds are likely to collide with the windows. This information could also be used to determine the best ways to alter building characteristics so as to minimize window-strike fatality frequencies.

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	Relative Percentage of Glass							
	Fairbanks	Gallahue	Holcomb	Pharmacy	HRC	J-G Bridge	G-Hbridge	H-PBridge
North	91.79	19.16	26.57	18.48	34.82	0	37.5	37.5
South	30.43	26.51	22.14	15.1	31.34	0	37.5	37.5
East	44.87	19.81	0	19.3	19.21	37.5	0	0
West	84.25	29.29	0	7.72	10.74	37.5	0	0

Table 1: Relative percentage of glass on each façade of the buildings and bridges characterized.

	Total Area of Glass							
	Fairbanks	Gallahue	Holcomb	Pharmacy	HRC	J-G Bridge	G-Hbridge	H-PBridge
North	5750	636	1561.5	1222.125	3475.75	0	270	225
South	1558	880.0968	2311.5	998.25	2861.864	0	270	225
East	2196	1790	0	2275.313	743.508	247.5	0	0
West	4354	2646.493	0	852.8438	447.5625	247.5	0	0

Table 2: Total area of glass on each façade of the buildings and bridges characterized. Measurements are given in units of sq. ft.

	Height of Building							
	Fairbanks	Gallahue	Holcomb	Pharmacy	HRC	J-G Bridge	G-Hbridge	H-PBridge
North	48	48	48	48	42	0	25.667	25.667
South	48	48	48	48	42	0	25.667	25.667
East	48	48	0	48	35	25.667	0	0
West	48	48	0	48	35	25.667	0	0

Table 3: Height of each of the buildings and bridges characterized. Measurements given in units of feet.

	Average Aspect Ratio							
	Fairbanks	Gallahue	Holcomb	Pharmacy	HRC	J-G Bridge	G-Hbridge	H-PBridge
North	2.338 to 1	1.62 to 1	1 to 1.378	2.2343 to 1	1 to 1.517	0	1.6 to 1	1.6 to 1
South	1.364 to 1	1.62 to 1	1.071 to 1	2.096 to 1	1 to 1.057	0	1.6 to 1	1.6 to 1
East	2.144 to 1	1.473 to 1	0	1.449 to 1	1.544 to 1	1.6 to 1	0	0
West	2.338 to 1	1.109 to 1	0	1 to 3.0838	1 to 1	1.6 to 1	0	0

Table 4: Average aspect ratio of the windows on each façade of the buildings and bridges characterized. Measurements given in units of ft. and are a height : width ratio.

Bird Window-strike Fatalities								
	Fairbanks	Gallahue	Holcomb	Pharmacy	HRC	J-G Bridge	G-H Bridge	H-P Bridge
North	-	1	4	0	-	-	2	3
South	-	1	1	0	-	-	2	0
East	-	1	-	0	-	4	-	-
West	-	4	-	0	-	1	-	-

Table 5: Bird Window-strike fatalities observed during the 2015 fall and 2016 spring migratory seasons. Dashes indicate no data was collected for these buildings during the 2015 fall and 2016 spring migratory seasons.