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The Effects of Tower Structure and Weather Conditions on Avian Mortality at Three Television Towers in Central Illinois

Lisa A. Lundstrom[1], David Joseph Horn[1]*, and Angelo P. Capparella[2]
[1]Department of Biology, Millikin University, 1184 W. Main St., Decatur, IL 62522, USA
[2]School of Biological Sciences, Campus Box 4120, Illinois State University, Normal, IL 61790, USA
*Correspondence: dhorn@mail.millikin.edu

ABSTRACT

Avian mortality has been documented at television towers and other constructed lighted structures for over 150 years, and it is estimated that 6.8 million birds are killed annually in the United States and Canada as a result of communication towers. Tower structure (lighting, height, and guy wires) and weather conditions (wind direction, cloud cover) play a large role in mortality rates. We examined the effects of tower structure and weather conditions on mortality at three television towers in central Illinois (WAND, WBUI, and WILL). Forty-three searches were conducted between August and November 2006-2009 with a total of 415 birds from 14 families found. Most birds found were of Family Parulidae (66%), Family Emberizidae (9%), and Family Turdidae (9%). The WILL tower accounted for 96% of the total birds killed. The high mortality observed at the WILL tower may be due to the tower's steady and flashing red lights as opposed to the flashing white lights on the WAND and WBUI towers. We found that more birds were killed following nights with winds from the north and ≥50% cloud cover. Most studies of tower collisions have focused on tower structure rather than weather conditions; however, the combination of tower lighting and weather may play a substantial role in avian mortality.

INTRODUCTION

Avian mortality associated with artificial lighting on human structures is thought to be a significant source of human-caused bird death (Evans 2007). The most recent mortality estimate at communication towers is 6.8 million birds per year in the United States and Canada; about 50% greater than the current estimate by the U.S. Fish and Wildlife Service (Longcore et al. 2012). Past studies have found that almost 95% of all birds that collide with lighted structures are neotropical migrants, particularly Family Parulidae (i.e. warblers; Longcore et al. 2013). The main factors associated with tower kills are tower structure (lighting, height, and guy wires) and weather conditions (Longcore et al. 2008; Gehring et al. 2009).

Artificial lighting affects the behavior of many plant and animal species, particularly at night (Rich and Longcore 2006). Species can be attracted to, or disoriented by, sources of artificial light through positive phototaxis (Verheijen 1985; Longcore and Rich 2004). This behavior in birds has been documented at communication towers for over 50 years as a result of the lighting systems required by the Federal Aviation Administration (FAA) (Gehring et al. 2009). Standard FAA lighting normally consists of a combination of steady and flashing red lights, although some towers use white lights instead. Previous studies have found that nocturnally migrating birds would fly around standard FAA lights of communication towers until the lights were turned off (Cochran and Graber 1958; Avery et al. 1977).

While the exact cause of this attraction is unknown, it is thought that migrating birds use both visual cues, such as stars, as well as an internal magnetic compass to navigate, and the artificial lighting somehow interferes with this (Gauthreaux and Belser 2006). For example, laboratory tests have suggested that the internal magnetic compass may be wavelength-dependent, with birds showing good orientation under white and green lights (Wiltschko and Wiltschko 1995) and disorientation under red light (Wiltschko et al. 1993).

In the presence of lighted towers, birds generally follow a circular, curvilinear flight pattern, and will continually circle around them until they collide with some part of the tower or its guy wires, or succumb to exhaustion and can no longer fly (Gauthreaux and Belser 2006). In an examination of the role of tower height and guy wires on avian mortalities, Gehring et al. (2011) found that there are 54—86% fewer fatalities at medium height, guyed towers (116—146 m) than at tall height, guyed towers (>305 m) and that guyed towers account for 16 times more bird fatalities than towers of the same height without guy wires.

While birds can collide with towers on clear nights, previous studies have found that larger numbers of birds are killed on fall nights with heavy cloud cover, northerly winds, and a low cloud ceiling when they do not have the stars to navigate by (Avery et al. 1977; Seets and Bohlen 1977; Larkin and Frase 1988; Kruse 1996). These conditions force birds to fly at lower altitudes within the range of towers, exposing them to tower structure risks.

We examined how the number of birds killed at one class of communication tower, tall television towers, was influenced by tower structure as well as cloud cover and prevailing winds during fall migration. While there have been many studies on the effects of tower structure, fewer studies have examined the role of specific weather conditions on the number of bird collisions (although see Longcore et al. 2012). We predicted that birds would experience the greatest mortality during nights with ≥50% cloud cover and predominantly northerly winds. By understanding the effects of weather and tower structure on mortality, we can make recommendations on ways to reduce avian mortality at television towers.

METHODS

We conducted our study at three television towers in central Illinois between August and November 2006—2009. The location of the towers were as follows: 1) WAND-TV tower, Macon Co.: Whitmore Twp. (T17N, R3E, S11), ca 2¼ mi. NE Oreana; 2) WBUI-TV tower, Macon Co.: Whitmore Twp. (T17N, R3E, S11), ca 2 mi. NE Oreana; and 3) WILL-TV tower, Piatt Co.: Willow Branch Twp. (T18N, R5E, S67/8), ca 5½ mi. W Monticello.

The towers were searched for carcasses on mornings following nights with four weather conditions: 1) ≥50% cloud cover and northerly winds, 2) ≥50% cloud cover and non-northerly winds, 3) <50% cloud cover and northerly winds, and 4) <50% cloud cover and non-northerly winds. Nights were classified using hourly weather observations from http://www.wunderground.com. To determine which morning to look for birds, we *a priori* selected days to search at the beginning of the fall season. To balance the number of searches by weather condition category, we did additional searches specific to those categories by monitoring conditions the previous evening and searching for birds that morning. Searches began at dawn to reduce carcass loss to scavengers (Crawford 1971).

At each of the three television towers, we first searched the paved and grassy areas just outside the tower facility. We then entered the facility and searched around the tower, including the roof. The areas under the guy wires were searched after harvest by walking straight paths from the tower base to the base of the three sets of guy wires and back, encompassing approximately 5 m to each side of the guy wires. Not searched was the extensive area between the guy wires. The area searched was similar between towers. However, because of differences in when crops were harvested, some towers may have been searched more extensively than others on certain visits. Nevertheless, the similarity in height and guy wire lengths among the towers should not result in significant bias in the number of dead birds found at each tower (Table 1). Carcasses that were not decomposed, based on the recession of the eyeballs, were transported to Millikin University for identification and further processing. For each bird collected, the date; tower; species; colors of the iris, maxilla, mandible, tarsi, and toes; and any other general remarks were recorded. Birds collected were deposited at the J.W. Powell-D. Birkenholz Natural History Collection at Illinois State University.

Table 1. Characteristics of three television towers and the landscape that surrounded each in central Illinois.

Chacteristic	WILL	WAND	WBUI
Tower Variables			
Tower Height	282 m[a]	379 m	390 m
Number of Wires	27	24	24
Guy-Wire Length	6202 m	Not determined[b]	5538 m
Number of Flashing Lights	3	13	13
Number of Steady Lights	12	0	0
Light-Pulse Frequency	30/min	40/min	40/min
Light Color	Red	White	White
Construction Color	Red/White	Steel	Steel
Landscape Variables			
Ground Elevation	210 m	209 m	208 m
Distance to Water Source	5.7 km	4.1 km	4.1 km
Distance to City	9.7 km	8.9 km	8.9 km

[a] Tower height and ground elevation were obtained from http://www.fccinfo.com.
[b] The exact guy-wire length could not be determined; however, the tower construction of WBUI and WAND is nearly identical. Therefore, we expect the guy-wire length to be similar.

We collected characteristics of each tower that could influence collision frequency. These included tower height, number of wires, guy-wire length, number of lights, light-pulse frequency, light color, tower color, ground elevation, and distance to nearest water source and city. Distance characteristics of each tower were measured using an Opti-Logic Laser Rangefinder.

We determined whether the number of dead birds collected per night was equivalent among our four weather categories using a chi-square test. A *P*-value of <0.05 was considered statistically significant.

RESULTS

Tower characteristics varied among our three towers (Table 1). In particular, tower height and lighting differed between WILL, WAND, and WBUI.

Forty-three searches were made between August and November 2006—2009. We found 415 birds from 14 families at the three towers, with the most birds from Family Parulidae (Table 2, n=272). The WILL tower had the most kills (n=397), followed by WAND (n=14), and WBUI (n=4). We recorded two kills with greater than 50 birds, the first on 4 October 2006 with 275 birds found, and the second on 28 October 2009 with 60 birds found.

We found that the number of birds killed was not equivalent in each of our four weather categories (Fig. 1, X^2=33.3, P<0.05). The majority of our birds were found fol-

Table 2. The number of birds found from each of 14 familes at 3 television towers in central Illinois from 2006-2009.

Family	Number of Fatalities
Parulidae	272
Turdidae	38
Emberizidae	38
Vireonidae	23
Regulidae	13
Troglodytidae	6
Cardinalidae	5
Icteridae	5
Mimidae	5
Certhiidae	2
Picidae	2
Tyrannidae	2
Unidentified	2
Cuculidae	1
Sturnidae	1

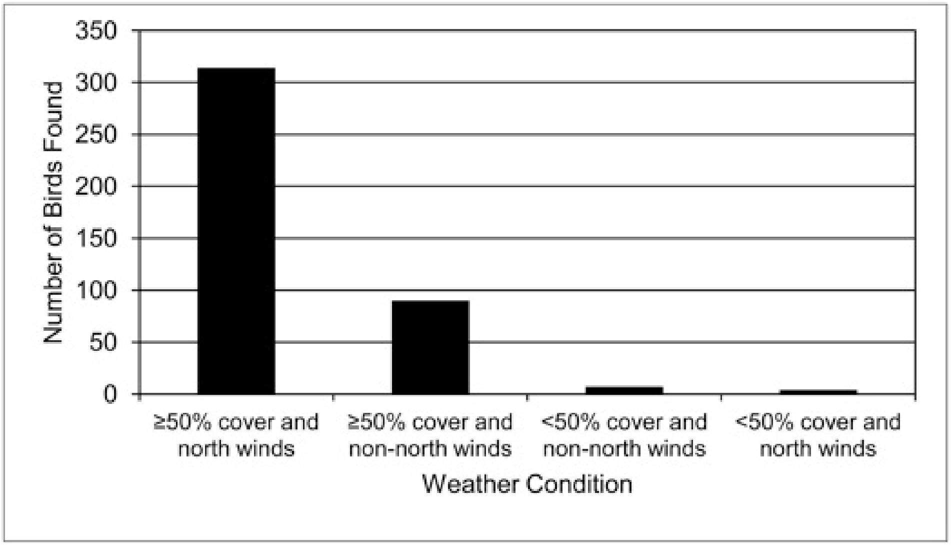

Fig. 1. The number of fatalities differed among weather conditions. More birds were found following nights with ≥50% cloud cover and northerly winds compared to other conditions (X^2 =33.3, *P*<0.05).

lowing nights with ≥50% cloud cover and northerly winds, with 304 individuals collected (73%). The nights that accounted for the second highest number of birds collected were nights with ≥50% cloud cover and non-northerly winds, with 98 individuals collected (24%).

DISCUSSION

Sixty-six percent of the birds found were members of Family Parulidae (i.e., warblers). Longcore et al. (2013) combined mortality data from previous studies to estimate mortality by species, and estimated that of the over 5,200,000 birds recorded, Family Parulidae accounted for 3,075,659 (58.4%). While a smaller percentage than ours, warblers had the highest mortality of any family-specific category.

Both of our large kills occurred at the WILL tower, which has steady and flashing red lighting. Gauthreaux and Belser (2006) compared bird flight patterns near towers with steady and flashing red lights, towers with only white strobes, and a control tower, which was unlit. They found that birds flew in straight paths over the control area, while birds flew in curvilinear paths and congregated near lighted towers. Between the two lighting categories used, they found that birds congregated in much higher numbers at towers lit with steady and flashing red lights than towers lit with white strobes, although the white strobes did have an effect on flight patterns.

Gehring et al. (2009) examined mortality rates between towers similar in construction, with different lighting systems. They attempted to determine whether mortality rates differed among towers equipped with flashing lights of various types and colors only versus towers equipped with the FAA standard combination of steady and flashing red lights. They found that more birds were killed at towers with steady and flashing red lights compared to towers with only white, flashing strobes; red, strobe-like lights; and red, flashing, incandescent lights (Gehring et al. 2009). Thus, the steady and flashing red lights on the WILL tower may explain why we observed 96% of our total kills at that location.

A correlation has been documented between tower height and mortality rates for towers with the same lighting scheme (Longcore et al. 2008; Gehring et al. 2011; Longcore et al. 2012). Our shorter tower experienced greater mortality than the two taller towers combined, but it had a different lighting scheme and more guy wires. The WILL tower has more guy wires per group and a combination of steady and flashing red lights, while the WBUI and WAND towers have fewer guy wires per group and flashing white lights. Studies have found that avian mortality increases with the number of guy wires present, but guy wires correlate with height (Longcore et al. 2008; Gehring et al. 2011). While our shorter tower (by 93 m) had more guy wires, it was only one more guy wire per group than each of the other two towers. Given the dramatic effect recorded for solid versus flashing lights (Gehring et al. 2009) and small difference in guy wire number, it is most likely that the lighting system of the WILL tower had a larger effect on mortality rates.

We found that more birds were killed following nights with ≥50% cloud cover and northerly winds, with our two largest kills occurring under these conditions at WILL. Longcore et al. (2008), through a meta-analysis of over 20 towers, found that the largest kills occurred on nights with heavy cloud cover in the presence of a combination of steady and flashing red lights. This suggests that while both weather and lighting play a large role separately, it is the combination of the two that may be most important.

While previous studies have reported higher kills following nights with heavy cloud cover (Avery et al. 1977; Crawford 1981; Larkin and Frase 1988), examinations of the combination of cloud cover and wind direction could be tested more rigorously. Most of our birds (73%) were found following nights with ≥50% cloud cover with the presence of northerly winds. This suggests that northerly winds in addition to heavy cloud cover create the most deadly conditions. However, in our study an additional 24% of birds were killed on nights with heavy cloud cover and non-northerly winds. Previous studies have concluded that while more birds are killed following nights with northerly winds than nights with non-northerly winds, overcast nights consistently experience mortality events regardless of wind direction (Avery et al. 1977; Crawford 1981; Larkin and Frase 1988).

Our estimates of mortality should be considered minimum values, as there were some possible sources of error in our study. We began our searches at dawn to lower the impact of scavengers, which can greatly reduce the number of carcasses (Crawford 1971). However, it is possible some carcasses were taken before we were able to collect them. We did not search the area between the guy wires, and thus, some birds will have been missed. In addition, we did not determine searcher efficiency. Finally, differences in harvest times between both tower sites and seasons meant that some towers were searched more extensively than others on some visits.

There are three main solutions to reduce avian mortality at television towers. The first would be to reduce tower height, as mortality risk increases exponentially with height (Longcore et al. 2012). The second solution is to reduce or eliminate the number of guy wires. Since guy wires account for the majority of bird kills due to the circling behavior of birds in the presence of tower lights, removing them could reduce collision rates (Brewer and Ellis 1958; Kruse 1996), but it is not possible for towers > 300 m (Longcore et al. 2012). Thus, while these two solutions will lower mortality rates, they are unlikely to happen, especially for towers that are already constructed.

The third solution is a change in tower lighting systems. Gehring et al. (2009) mainly suggested the removal of non-flashing red lights leaving only the flashing red strobe, but recommended a color change to white strobes as well. Taylor (1981) recorded a drastic reduction in fatalities at a Florida tower when the lighting system was changed from steady and flashing red lights to white strobe lights.

Arnold and Zink (2011) suggest that while millions of birds are killed by collisions, not only with communication towers but with other constructed structures, it may not have a significant effect on population trends. However, mortality rates are not the same for all species (Longcore et al. 2013). Longcore et al. (2013) found that some species, including U.S. Fish and Wildlife Service Birds of Conservation Concern, are suffering losses of several percent of their estimated population size. Because of the differences in mortality rates between species, Longcore et al. (2013) suggest per species estimates are undertaken for all human-caused sources of avian mortality.

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