AVIAN WINDOW STRIKE MORTALITY AT A SUBURBAN OFFICE PARK

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ABSTRACT

From May 1993 to May 1994, I recorded incidences of window strike mortality at four glass-surfaced buildings in a corporate office park in suburban Richmond, Virginia. Each building was checked for dead birds by walking the perimeter of the building approximately weekly. Individual victims were counted and identified to species, depending on the state of preservation. I documented 116 individuals of 40 species killed at the four buildings, with a mean annual mortality rate of 29 individuals killed per building. This rate is nearly three times the carefully derived and independently verified estimated rate of ten birds/building/year, suggesting that structures with high rates of bird strikes can indeed compensate for structures with low incidences of bird strikes in continental scale estimates of window-strike mortality. Unlike previously published reports on bird-window collisions, mortality in this study was significantly higher in the spring and fall than in winter. I also documented a disproportionately low incidence of mortality among birds attracted to feeders and a high incidence of mortality in long distance migrants. Window-strike mortality at office parks may mimic more closely the type of mortality documented at certain well-known skyscrapers than it does the mortality observed at private residences with feeding stations.

INTRODUCTION

Reports of dramatic bird kills at communications towers have recently garnered media attention as the construction of thousands of new towers is contemplated following passage of the Telecommunications Act of 1996 (Ornithological Council 1999). Lighted towers can confuse migrating birds that are drawn to the light, particularly during periods of light rain or fog. As birds repeatedly circle around the lighted area, they may be injured or die from collisions with the tower itself, guy wires, or other birds (Cochran and Graber 1958, Avery et al. 1976). Isolated instances of massive kills (e.g., thousands of birds in a single night) have been reported from individual towers. At least one on-line compilation estimates that approximately 5 million birds are killed annually in North America from collisions with towers (www.towerkill.com). The 1998 report from the resolutions committee of the North American Ornithological Conference (David Blockstein, Chair) urged the telecommunications industry, the United States Fish and Wildlife Service, the Federal Aviation Administration, and the Federal Communications Commission to work together to study the phenomenon and ultimately devise means to reduce bird mortality from tower collisions.

Similar to tower mortality, large numbers of birds also die annually from collisions with skyscrapers and other tall buildings. Buildings close to waterfront areas on important migration pathways (e.g., Chicago, Toronto, New York City) can be especially problematic to nocturnal migrant birds. For example, volunteers collected approximately 2900 dead and injured birds in downtown Toronto, Ontario in 2000. As with towers, lights shining on and from within buildings disorient migrant birds and lead to collisions (Fatal Light Awareness Program, www.flap.org).

Despite startling reports of bird mortality from specific buildings or towers, bird mortality from striking windows is a more insidious, and perhaps more serious, problem for bird conservation. Window-killed birds are typically claimed (at any time of day) by simply not recognizing reflective glass as a barrier. Window kills often occur in residential neighborhoods where landscaping is reflected in windows creating the illusion of continuous vegetation, or where the glass reflects the sky and creates the illusion of a clear flight line (Klem 1989).

Klem (1990a) produced an estimate of the numbers of birds killed annually by striking windows in the United States, and provides a convincing argument to regard the assessment as conservative. His estimate of 1-10 fatalities/building/year places the total number of fatalities somewhere between roughly 97 million and 975 million birds per year. Dunn (1993) provided an independent assessment of mortality rate (0.65 –7.70 fatalities/home/year) from the Cornell Laboratory of Ornithology's Project FeederWatch data that matches closely with Klem's estimate. These estimates are based largely on data from mortality at private residences, and do not include data from kills at towers or skyscrapers.

Klem and Dunn's independent estimates of mortality from window collisions, while disturbing, have been slow to attract the widespread attention of conservationists, either due to ignorance (Klem 1991) or perhaps because of the wide range in the predicted number of fatalities casts doubt on the overall impact. It may not be possible, however, to improve the precision of such estimates because so many factors operate in determining the likelihood that a bird will strike a window on any given building. We do know that certain buildings, due to their location near high densities of birds attracted to feeding stations, their location along routes heavily used by migrants, or merely due to the particularly confusing reflections that their windows produce, kill far more than a single bird annually (Klem 1989, 1990a, 1991, Dunn 1993). Elevated mortality rates at these buildings may compensate for buildings at which no mortality occurs to maintain the continental mortality rate at 1-10 fatalities/building/year, but there is little quantitative data to support this contention (Klem 1990a). My objective in this paper is to describe a situation in which several buildings exhibited high rates of window strike mortality, and suggest that the conditions that made these buildings particularly deadly for birds may be rather common.

STUDY AREA AND METHODS

From May 1993 to May 1994, I counted window-killed birds around the perimeters of four office buildings in suburban Richmond, Chesterfield County, Virginia (approximately 37° 31' N, 77° 32' W). This rapidly urbanizing region of Chesterfield County lies within the Piedmont Physiographic Province, several kilometers west from the fall line of the James River marking the edge of the Coastal Plain (Woodward and Hoffman 1991). All four buildings were located in a corporate office park setting adjacent to high intensity residential development and a busy commercial thoroughfare. Two of the buildings were situated close enough to afford views of a small (approximately 1 ha), artificial lake and naturalistic walking trail on an unnamed tributary to Powhite Creek. The remaining two buildings were situated across a four-lane, divided avenue, and within roughly 100 m of a four-lane highway. Strips and small patches of mature second growth forest were preserved as open space in the development. Forested areas were characterized by an overstory of Virginia pine (*Pinus virginiana*), red oak (*Quercus rubra*), white oak (*Q. alba*), tuliptree (*Liriodendron tulipifera*) and sweetgum (*Liquidambar styraciflua*).

All four buildings were irregular in shape (i.e., more than 4-sided) and contained large expanses of tinted, mirrored glass in various configurations from ground level to the roof. All buildings were four to six stories in height, and surrounded by ornamental shrubs, lawns, and paved parking areas. The entire office park was maintained by a professional landscaping crew and grassy areas were heavily watered and lush. The office park contained several additional buildings, some of which also included mirrored glass exteriors and claimed birds, but these were not included in my observations. I selected the four buildings in this study after first noticing dead birds at the base of one of the buildings; I then developed a walking route that would allow me to efficiently sample the buildings.

The perimeters of all four buildings in this study were adjacent to sidewalk, paved parking area, mowed lawn, pine bark mulch, or evergreen shubs. With the exception of approximately 15 m along one side of one building that was densely vegetated, I was able to access the entire perimeter of each building with a clear view from the building's base out to approximately 3 m. Thus I am confident that I was able to detect close to 100% of the carcasses in this zone. Neither Klem (1990a) nor Dunn (1993) provide detailed information on visual detection probabilities, most likely because they are assumed to approach 100%.

I searched the perimeter of each building for dead birds approximately weekly (50 total surveys). If a thunderstorm or strong front moved through the area, I conducted my search as soon as possible after its passage, rather than wait a full week until my next search. I assumed that any dead birds found at the base of the buildings were healthy individuals that died from colliding with glass surfaces on the buildings' exteriors. All casualties were counted and identified to species, sexed, and aged if possible. I delivered particularly fresh specimens to the vertebrate collections of Virginia Commonwealth University, Richmond, Virginia, under the curation of Dr. Charles Blem.

I compiled data on a year of window strike mortality for each building individually and a total list for all four buildings. For comparison with other datasets of window-killed birds, I described the total list in terms of life history guild composition (Ehrlich et al. 1988). I compared the proportion of residents, temperate migrants, tropical migrants, and birds that frequent feeding stations in the 15 most commonly recorded fatalities between my sample and those reported in Klem (1990a). To identify seasonal peaks in mortality, I applied one-way ANOVA with Tukey's multiple comparisons procedure, coding calendar dates as factor levels in the ANOVA model (Neter et al. 1990). I examined seasonality by testing for differences in "calendar" seasons delimited by the equinoxes and solstices, and also by seasons defined by bird migratory behavior. The "bird-defined" seasons were: 1 April – 31 May (spring), 1 June – 31 July (summer), 1 August – 15 November (autumn), and 16 November – 31 March (winter). I used a square root transformation on the response variable in the ANOVA models to provide homogeneity of variance among factor levels.

Both Klem (1990a) and Dunn (1993) mention that predators and scavengers likely take many window-killed bird carcasses before the mortality can be recorded. My study area supported raccoons (*Procyon lotor*), opossums (*Didelphis virginiana*), gray squirrels (*Sciurus carolinensis*), American Crows (*Corvus brachyrhynchos*), and feral cats (*Felis catus*) in abundance, and some carcasses were doubtless removed before I tallied them. In addition, maintenance crews routinely ran lawnmowers over bird carcasses to remove them from where they could be seen by building patrons. This bias may have influenced my sample to a greater degree than previous studies because I only checked buildings approximately weekly as opposed to daily (e.g., Klem 1989). Also, the buildings' residents in my study were not specifically involved in an effort to document bird mortality at their windows as were the Project FeederWatch participants (Dunn 1993). Despite the seeming increased risk of my sample being subject to a larger proportional removal bias, many of the carcasses I encountered at all four buildings were badly decayed, and had apparently been lying on the ground for several days. This suggests that removal bias may have had limited impact on my results.

RESULTS

I documented 116 birds of 40 species killed by striking the four buildings in my sample (Table 1). The four buildings yielded 38 individuals of 18 species, 21 individuals of 18 species, 27 individuals of 19 species, and 30 individuals of 20 species, respectively. The mean number of individuals killed per building throughout the year-long sampling period was 29 ±7.07. I recorded a mean number of fatalities per week of 2.32 ±2.32 for all four buildings, combined.

Of the 40 species documented as fatalities in my sample, 19 were long-distance migrants, 12 were short-distance migrants, and 9 species were annual residents in the study area. Six species in my sample (Dark-eyed Junco, Downy

Table 1. Total avian window strike fatalities recorded at the four buildings in the study area, May 1993 – May 1994. Taxonomy follows the American Ornithologists' Union 7th edition check-list (1998).

Common Name	Scientific Name	Total
American Robin	*Turdus migratorius*	9
Yellow-bellied Sapsucker	*Sphyrapicus varius*	7
Black-throated Blue Warbler	*Dendroica caerulescens*	7
Black-and-white Warbler	*Mniotilta varia*	7
Dark-eyed Junco	*Junco hyemalis*	7
Ruby-crowned Kinglet	*Regulus calendula*	5
Golden-crowned Kinglet	*Regulus satrapa*	5
Wood Thrush	*Hylocichla mustelina*	5
Yellow-rumped Warbler	*Dendroica coronata*	5
Veery	*Catharus fuscescens*	4
Ovenbird	*Seiurus aurocapillus*	4
Mourning Dove	*Zenaida macroura*	3
Yellow-billed Cuckoo	*Coccyzus americanus*	3
Brown Creeper	*Certhia americana*	3
Indigo Bunting	*Passerina cyanea*	3
Northern Flicker	*Colaptes auratus*	2
Chimney Swift	*Chaetura pelagica*	2
Great Crested Flycatcher	*Myiarchus crinitus*	2
Swainson's Thrush	*Catharus ustulatus*	2
Gray Catbird	*Dumetella carolinensis*	2
Northern Mockingbird	*Mimus polyglottos*	2
Swamp Sparrow	*Melospiza georgiana*	2
Common Grackle	*Quiscalus quiscula*	2
House Finch	*Carpodacus mexicanus*	2
Sharp-shinned Hawk	*Accipiter striatus*	1
Belted Kingfisher	*Cerle alcyon*	1
Downy Woodpecker	*Picoides pubescens*	1
Red-eyed Vireo	*Vireo olivaceus*	1
House Wren	*Troglodytes aedon*	1
Gray-cheeked Thrush	*Catharus minimus*	1
Hermit Thrush	*Catharus guttatus*	1
Brown Thrasher	*Toxostoma rufum*	1
Nashville Warbler	*Vermivora ruficapilla*	1
Northern Parula	*Parula americana*	1
Blackpoll Warbler	*Dendroica striata*	1
American Redstart	*Setophaga ruticilla*	1
Northern Waterthrush	*Seiurus noveboracensis*	1
Eastern Towhee	*Pipilo erythophthalmus*	1
White-throated Sparrow	*Zonotrichia albicollis*	1
House Sparrow	*Passer domesticus*	1
unknown thrush	*Catharus sp.*	1
unknown waterthrush	*Seiurus sp.*	1
unknown warblers	*Parulidae*	3

Woodpecker, House Finch, House Sparrow, Mourning Dove, and White-throated Sparrow) could be considered "feeder birds" due to their propensity to occur around feeding stations. Figure 1 illustrates the number of birds in various life history guilds among the 15 most-reported fatalities in my sample and in the data compiled by Klem (1990a).

Window-strike mortality peaked in my sample during periods of bird migration. Maximum casualties per week were recorded for samples taken on 12 May 1993 and 27 April 1994 (9 individuals each) and on 6 October 1993 (8 individuals). Mean casualties per week were highest during autumn (3.33 ±2.35) and spring (2.73 ±3.01), followed by summer (1.46±0.97) and winter (0.86±0.90). Seasonal differences, however, were not statistically significant when I used seasons defined by equinoxes and solstices ($F_{3,49} = 2.60$, $P = 0.063$). When I defined seasons by avian migratory behavior, seasonal differences in mortality were significant and higher in autumn and spring than in summer and winter ($F_{3, 49} = 4.47$, $P = 0.008$, 95% confidence intervals for Tukey's multiple comparisons did not include zero).

DISCUSSION

The annual mortality rate at the buildings in my sample (21-38, mean = 29) was consistent with that reported for other structures known to claim an unusually high number of victims. Klem (1990a) reports that annual window collisions at a home in Carbondale, Illinois claimed 33 victims; 26 individuals were killed in one year from striking windows at a home in Purchase, New York. Of the 507 participants in Project FeederWatch who reported window strike mortality during the winter of 1989-1990, six tallied ten or more fatalities in a four-month observation period, i.e., at least 30 annual fatalities given a consistent rate (Dunn 1993).

Because the buildings in my sample were not homes that attracted birds to a supplemental food source, the composition of the most commonly killed birds in my sample differs from that reported by Klem (1990a). Considering only the 15 most often recorded casualties (Fig. 1), my sample is characterized by a dearth of "feeder" birds and residents, and more long-distance than short-distance migrants. Klem's (1990a) sample includes a large proportion of feeder birds and more short-distance than long-distance migrants.

Notably absent from my sample were abundant local residents such as Carolina Chickadee (*Poecile carolinensis*), Tufted Titmouse (*Baeolophus bicolor*), Carolina Wren (*Thryothorus ludovicianus*), and Red-bellied Woodpecker (*Melanerpes carolinus*). Blem and Willis (1998), in a survey of the Virginia Commonwealth University Ornithological Collection, list House Sparrow, Brown-headed Cowbird (*Molothrus ater*), and Common Yellowthroat (*Geothlypis trichas*) as the most abundant victims of "human-caused mortality" in the greater Richmond, Virginia area. These three species are represented in my sample by a single House Sparrow.

The paucity of abundant breeding and "feeder" species in my sample and the presence of many migrants that did not breed in the study area suggests that most of the mortality I observed affected migrants in passage. This observation is

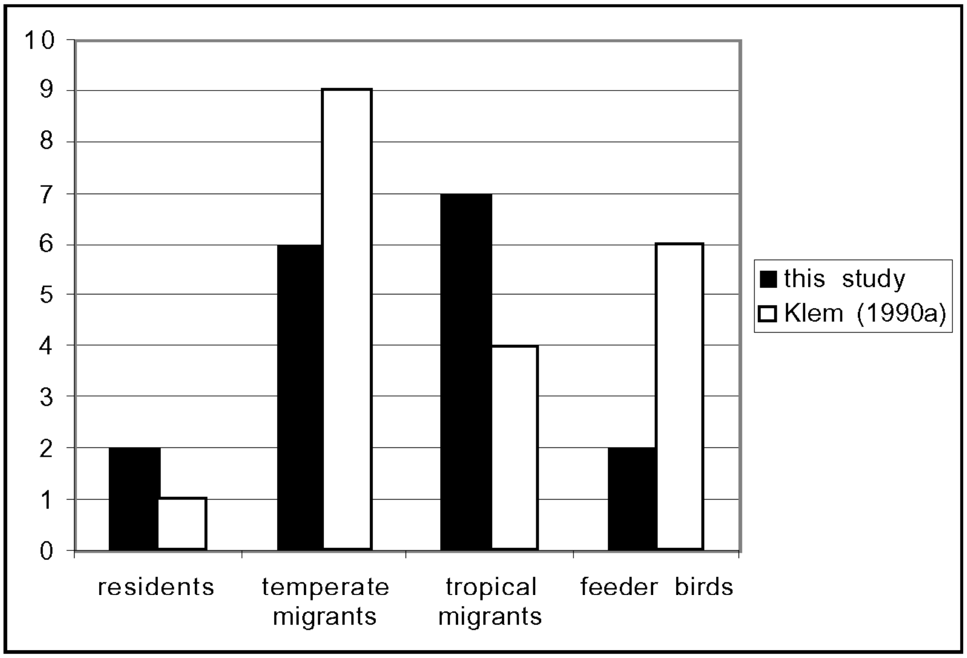

Figure 1. Life history guild composition of the 15 most frequently recorded avian window strike fatalities in this study compared to the data presented in Klem (1990a). Resident birds (e.g., Mourning Dove) occur in an area in all seasons; temperate migrants (e.g., Brown Creeper) winter south of their breeding range, but generally within the continental United States; tropical migrants (e.g., Black-and-white Warbler) typically winter south of 30∞ latitude. Feeder birds (e.g., House Sparrow) are those that frequent feeding stations. Note that the numbers for each study do not sum to 15 because "feeder birds" are not mutually exclusive with migratory behavior.

supported by the significantly greater mortality observed during spring and fall migration than during the winter months when mortality of feeder birds is presumably the greatest. Thus, the mortality I observed at a suburban office park may be more similar to that observed in large cities on major migration pathways, e.g., downtown Toronto, Ontario, Canada (FLAP, www.flap.org), than it is to mortality observed at homes with feeding stations.

Because my study area was not located along a particularly well-defined migration route, I can only speculate on the cause for so much mortality in the office park I sampled. Perhaps the mere combination of mirrored glass exteriors and a forested corridor was enough to place many birds moving through the area at risk of collision. Although most of the forested patches and strips in the development were small, the buildings tended to reflect those patches and create the illusion of more extensive forest. The presence of permanent water may have also attracted migrants in need of a stopover site while traversing a large metropolitan area.

I compared my data with other samples of window strike mortality (e.g., Klem 1990a, Dunn 1993). This assumes that all observers in all studies have an equal probability of detecting bird carcasses along the perimeters of buildings. Klem's estimate is derived from data collected personally, data submitted by homeowners participating in the study, and museum records from a multitude of sources (Klem 1990a). Dunn's estimate is derived from observations submitted by 1165 participants in Project FeederWatch (Dunn 1993). There has been no concerted effort to standardize methods for quantifying window kills, and all sources are likely subject to biases. For example, it is possible that some birds are killed at windows, but the carcass is hidden or inaccessible in vegetation. Predators and scavengers may remove injured and dead birds around the base of buildings before the birds can be tallied by human observers. Finally, many birds hit windows and fly away seemingly unharmed but ultimately succumb to injuries sustained in the collision (Klem 1990b).

Biases in detection probabilities for window-killed birds share one thing in common – they all lead to underestimates of the full biological effect of window-strike mortality for wild birds. Until methods for standardizing the collection of such data can be adopted, we can only speculate that these biases affect all studies equally. Klem (1990a) and Dunn (1993), using very different protocols, arrived at similar estimates on the rate of continental scale window-strike mortality. My methods (perimeter search around buildings) were similar to those employed in previous studies.

Whatever the specific causes for the mortality I observed, it is clear from a local conservation standpoint that the number of birds killed in this one office park is non-trivial. My overall estimate of annual mortality is roughly three times Klem's (1990a) upper estimate for window strike mortality in general, and provides support that certain buildings may easily compensate in the overall estimate for those at which mortality does not occur. Also, while not explicitly stated, Klem's (1990a) assertion that high-mortality buildings will compensate for low-mortality buildings in his overall estimate probably assumes that high mortality occurs at two types of buildings: private homes with feeding stations and large buildings along migration corridors. My observations document mortality like that witnessed at large buildings along migratory corridors, but in a largely residential suburban landscape. Furthermore, I did not observe high mortality at a single, unusually deadly building, but rather at four separate, well-spaced buildings in the development. This fact leads me to conclude that any similar combination of reflective glass, naturalistic landscaping, and a permanent water source could create a "migrant trap" in a most unfortunate sense of the term.

Future research in window-strike mortality would benefit greatly from standardization of detection methods and quantification of detection biases. To date, researchers have only been able to identify the biases and explain how they lead to conservative estimates of mortality. Efforts to better quantify and account for detection biases, as well as sampling from randomly selected houses and neighborhoods, could potentially refine estimates of continental scale mortality from window collisions. These advancements may be necessary before the larger conservation community can confidently stand behind efforts to help solve the problem.

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