Maryland Birdlife 64(2):23-33

An Evaluation of Species Diversity and Age Structure during Fall Migration Mortality from Urban Structures in Baltimore, Maryland and Washington, District of Columbia

Mark S. Johnson[1, 2], Leslie R. Eastman[1], Robert J. Werrlein[1], and Jay M. Rubinoff[1]

[1]*Eden Mill Nature Center, 1617 Eden Mill Road, Pylesville, Maryland 21132*
[2]*Corresponding author: mark.steven.johnson@comcast.net*

ABSTRACT: Collision mortality of Neotropical migratory songbirds has long been associated with attraction and disorientation associated with artificial lighting, particularly in large metropolitan areas. Observation of avian injuries and mortalities caused from impact with windows during migration has been well documented. Age structure is also an important factor in assessing population resiliency. Older birds are typically more effective in producing young as they tend to arrive earlier, occupy higher quality territories, and produce greater clutch sizes than yearling (Hatching Year) birds. We used standardized banding procedures to determine the age and sex of 462 individuals of 51 species collected during the fall migration in Baltimore, Maryland and Washington, District of Columbia in 2010 and 2011. Collectors used a consistent route during a specific time interval to retrieve birds found in the downtown areas of both cities. Birds were frozen and subsequently aged and sexed, when possible, following the collection for each migration period. A chi-square test of homogeneity (goodness-of-fit) was performed to determine if the overall distribution of After Hatching Year (AHY) and Hatching Year (HY) birds was different than a 1:1 ratio. A chi-square test of independence (association) was performed to examine the relationships between age and location, sex, and year. Sex had the largest influence on age, where 62% of the birds sexed as unknown were more likely to be aged HY. Birds collected in Baltimore were more likely to be HY (59%) than those collected in DC (49%). The distribution of AHY (41%) to HY (59%) of birds killed in 2010 was different than a 1:1 ratio; however, in 2011 it was not. Year did not have an effect on the age distribution and did not differ more than 6%. Together, the mean proportions of AHY and HY birds were largely equivalent, whereas proportions of HY birds reported by local banding stations outside these metropolitan areas during this period were suggestive of higher proportions of HY birds, implying that the detrimental influence of impacts with buildings in metropolitan areas may have a much greater effect on populations than previously considered.

Figure 1. Representative bird causalities collected from metropolitan District of Columbia in fall 2010. (Photo courtesy of City Wildlife).

INTRODUCTION

Avian mortality resulting from building and window collisions on nocturnal migrating Neotropical migrants is well documented (Figure 1) (Evans Ogden 1996, Klem 2009; but see Gauthreaux and Belser 2006 for a review). Songbirds have been reported to experience the greatest rates of mortality, particularly those that travel the greatest distances (Arnold and Zink 2011). Banks (1979) estimates that approximately 1.25 million birds are killed in North America each year due to collisions with television towers. Klem (1990) and Dunn (1993) estimate that mortality due to window collisions are between 100 million and one billion birds/year, and Loss et al. (2014) provided estimates that included low and high rise buildings with mortality estimates of 365-988 million birds annually (median = 599 million). These estimates are similar to those estimated from encounters with feral cats, wind turbines, and communication towers (Manville 2005, Klem 2010, Longcore et al. 2012, Loss et al. 2013). Despite these estimates, the relative influence of building-strikes resulting in mortality events contributing to population decreases compared to nest predation and collisions with radio towers, high wires, and other manmade objects has not been determined. Arnold and Zink (2011), however, used collision data from multiple sources and compared those records with trend data from the North American Breeding Bird Survey. They found only a weak positive correlation ($r = 0.154$) and suggested that species impacted by collisions with buildings were likely to have population increases. Results were variable and relationships were weak.

Age-related increases in offspring production have also been documented for several species of birds (Saether 1990, Holmes et al. 1992, Martin 1995). Additionally, nest success and site fidelity have been correlated (Darley et al. 1977, Lozano and Lemon 1999). Birds in their second reproductive year or older tend to produce more offspring for a variety of reasons. Older birds tend to arrive at breeding sites earlier, have larger clutch sizes, and fledge more young than birds in their first reproductive year (Saether 1990, Martin 1995, Roth et al. 1996). Understanding the age-specific rates in mortality of migratory birds during building and window collisions is important in estimating long-term effects to populations.

Banders routinely age and determine sex for many species and publish these data as part of avian monitoring efforts. Some sources are the data compiled and published in *North American Bird-Bander* in the Atlantic Flyway Reviews (Robbins 2011, 2012). Here we report species diversity and age profiles of birds collected as part of urban avian mortality monitoring efforts and compare these relationships with data collected from local banding stations to infer on the relative importance of window and building collisions to the impact of these events on populations.

METHODS

Birds resulting from building collisions in downtown Baltimore, Maryland, and Washington, District of Columbia (DC) were collected as part of a standardized monitoring effort during the falls of 2010 and 2011. Briefly, volunteers canvassed specific predetermined routes in the downtown areas of each city beginning in the predawn hours covering approximately 4 km (2.5 mi) from August through November. The Baltimore route included the nearby harbor area and the DC route was close to a green space mall area with water nearby. Birds that were alive were immediately transferred to wildlife rehabilitators for assistance; those killed were placed in plastic bags along with notes on location and time. In most cases, location included specific addresses and building identification. Birds were then frozen, collected at a single coordination site, assigned to a species, and aged and sexed by the authors using Pyle (1997). Martin (1964) was used to determine age and sex for American Woodcock (*Scolopax minor*). The extent of skull pneumatization could not be performed given the frozen condition of the carcasses. Only birds collected as part of canvassing this consistent route were evaluated.

A chi-square test of homogeneity (goodness-of-fit) was performed to determine if the overall distribution of After Hatching Year (AHY) versus Hatching Year

(HY) birds killed was significantly different. In other words, the test of homogeneity determined if there was a 1:1 ratio of AHY to HY birds killed. A chi-square test of independence (association) was performed to examine the relationship between age and location, sex, and year. Standardized residuals were also used to determine exactly where the largest, and in turn, most significant differences were located within each cross tabulation. Due to small sample sizes, After Second Year (ASY) and After Third Year (ATY) were combined with AHY to create one AHY category. All Unknown (U) ages were excluded.

RESULTS

Over 607 birds were collected as part of this effort during the falls of 2010 and 2011. However, because of condition, age could only reliably be determined for 462 individuals representing 51 species. The top ten encountered species are presented in Table 1. Together, they constituted 74% of the total evaluated. Over 20 species of warblers (Parulidae) were collected. Five *Catharus* thrush species, as well as six American Woodcock, and four White-breasted Nuthatches (*Sitta carolinensis*) were of interest.

Table 1. Top ten species collected during 2010 and 2011 fall migration collection events in downtown Baltimore and District of Columbia.

Common Name	Scientific Name	ALPHA code	%	N
White-throated Sparrow	*Zonotrichia albicollis*	WTSP	30	103
Common Yellowthroat	*Geothlypis trichas*	COYE	20	69
Gray Catbird	*Dumetella carolinensis*	GRCA	11	37
Ovenbird	*Seiurus aurocapilla*	OVEN	10	35
Swamp Sparrow	*Melospiza georgiana*	SWSP	7	24
Song Sparrow	*Melospiza melodia*	SOSP	7	24
Hermit Thrush	*Catharus guttatus*	HETH	4	15
Dark-eyed Junco	*Junco hyemalis*	SCJU	4	13
Wood Thrush	*Hylocichla mustelina*	WOTH	3	12
Yellow-bellied Sapsucker	*Sphyrapicus varius*	YBSA	3	12

Sex of collected birds had the largest influence on age (Table 2). Those categorized as unknown for gender were significantly more likely to be HY age (62%), as opposed to AHY (38%) ($N = 462$, $df = 2$, $p < 0.001$). This was expected given that age cannot reliably be determined in many species of young HY birds (Pyle 1997). Due to the large number of birds of unknown sex (AHY [N = 108] and HY [N = 179]), few correlations could be made between sex and age.

Table 2. Sex of collected birds versus age. Results of the chi-square homogeneity (goodness-of-fit: a) and association (independence: b & c) of age and sex of birds collected during 2010 and 2011 fall migration surveys in downtown Baltimore and District of Columbia.

		Age		
Sex		**AHY**	**HY**	**Total**
Female	Count	35	16	51
	% within Sex	68.6%	31.4%	100.0%
	Standardized Residual	2.6	-2.3	
Male	Count	63	61	124
	% within Sex	50.8%	49.2%	100.0%
	Standardized Residual	1.0	-0.9	
Unknown	Count	108	179	287
	% within Sex	37.6%	62.4%	100.0%
	Standardized Residual	-1.8	1.6	
Total	Count	206	256	462
	% within Sex	44.6%	55.4%	100.0%

Collection location also influenced age to a small extent (Table 3). Those located in Baltimore were more likely to be HY (59%), as opposed to AHY (41%) when compared to those found in DC (HY [49%], AHY [51%]; $p < 0.030$).

Table 3. Collection location versus age. Results of the chi-square homogeneity (goodness-of-fit: a) and association (independence: b & c) of age and collection location of birds collected during 2010 and 2011 fall migration surveys in downtown Baltimore and District of Columbia.

		Age		
Location		**AHY**	**HY**	**Total**
Baltimore	Count	119	173	292
	% within Location	40.8%	59.2%	100.0%
	Standardized Residual	-1.0	0.9	
DC	Count	87	83	170
	% within Location	51.2%	48.8%	100.0%
	Standardized Residual	1.3	-1.2	
Total	Count	206	256	462
	% within Location	44.6%	55.4%	100.0%

The distribution of AHY (41%) to HY (59%) birds killed in 2010 was different than a 1:1 ratio (N = 202, df = 1, $p < 0.02$) (Table 4). However, in 2011, the difference (AHY [47%]; HY [53%]) was not different than a 1:1 ratio (N = 260, df = 1, $p = 0.39$). Collection year proved to not have a statistically significant effect on age distribution; however AHY and HY proportions did differ by approximately 6% between 2010 and 2011 ($p = 0.182$).

Table 4. Collection year versus age. Results of the chi-square homogeneity (goodness-of-fit: a) and association (independence: b & c) of age and collection year of birds collected during 2010 and 2011 fall migration surveys in downtown Baltimore and District of Columbia.

		Age		
Year		**AHY**	**HY**	**Total**
2010	Count	83	119	202
	% within Year	41.1%	58.9%	100.0%
	Standardized Residual	-0.7	0.7	
2011	Count	123	137	260
	% within Year	47.3%	52.7%	100.0%
	Standardized Residual	0.7	-0.6	
Total	Count	206	256	462
	% within Year	44.6%	55.4%	100.0%

DISCUSSION

There are differences between species in their probability for collisions with urban buildings. Species with a relatively high incidence (termed “super colliders”) were 25 to 57 times more likely than others to collide with a building (Arnold and Zink 2011). According to Arnold and Zink (2011), the five top species identified as colliders with buildings were Swamp Sparrow (*Melospiza georgiana*), Brown Creeper (*Certhia americana*), Black-throated Blue Warbler (*Setophaga caerulescens*), Nelson’s Sparrow (*Ammodramus nelsoni*), and Fox Sparrow (*Passerella iliaca*). In the present study, the top five colliders were: White-throated Sparrow (*Zonotrichia albicollis*, N = 103), Common Yellowthroat (*Geothlypis trichas*, N = 69), Gray Catbird (*Dumetella carolinensis*, N = 37), Ovenbird (*Seiurus aurocapilla*, N = 35) with Swamp Sparrow (N = 24) and Song Sparrow (*Melospiza melodia*) (N = 24) tied at fifth. Interestingly, these species are typically within the top ten for many banding stations in the Mid-Atlantic Region during this time period (Robbins 2012). Some species, because of life history or physiological characteristics are at greater risk of fatality from building collisions. However, data from local banding stations suggest that flight frequency, timing, and group density of some migratory species may also increase their probability of risk of collision mortality.

Greater mortality of naïve individuals (e.g., yearlings) has been suggested during long migratory events (Sherry and Holmes 1995). Older, experienced breeders have the greatest potential for reproductive success and therefore affect population growth rates (Saether 1990, McDonald and Caswell 1993, Martin 1995). The data collected from the present study found that proportions of AHY and HY birds collected post mortem from downtown Baltimore and the District of Columbia were not different, whereas during this period proportions of HY birds banded at nearby banding stations were largely higher, likely a result of offspring born that year (HY birds). This suggests that a significant proportion of birds killed from building collisions are experienced, post-breeding adults. In 2010, there was a slightly larger proportion of HY birds (59%) that were killed compared to AHY (41%); in 2011 the difference was not much different from a 50:50 distribution. These data are in marked difference from those collected at nearby banding locations where during this same period, the mean percentage of HYs was 84% in 2010 and 79% in 2011 (Robbins 2011, 2012). These included data from banding stations in the Maryland Piedmont (Eden Mill, Laurel, and Patuxent) and Coastal Plain (Foreman's Branch and Kiptopeke). The banding station with the highest percentage of HYs (i.e., Kiptopeke) was 92% and 95% in 2010 and 2011 (mean values for both years provided in Figure 2), respectively, approximately 40% higher in 2011 than the results from building collisions presented here. These results suggest that a greater proportion of older birds are striking buildings as a result of nocturnal collisions in metropolitan areas—birds most productive in producing offspring.

These comparisons, however, must be considered preliminary and are not without assumptions. Birds processed as part of banding operations are typically captured at low heights (up to 3 m [10 ft]), whereas migrating birds collected at ground level after impact with tall buildings may have collided at higher levels. Other investigators have reported that 90% of collisions occur in the first 12 m [39 ft] above ground level (Evans Ogden 1996; but also see Loss et al. 2014). Additionally, banders use skull pneumatization as a means for determining age; this was not feasible for the birds collected and stored frozen. Lighted buildings/structures have been suggested by many as an attractant (Evans Ogden 1996, Jones and Francis 2003, Manville 2005, Gauthreaux and Belser 2006). Banding stations often operate during daylight hours away from urban areas.

Although Arnold and Zink (2011) did not find a strong relationship between species found to be "super colliders" and population trends reported from data collected in the Breeding Bird Survey (BBS), there are several plausible explanations for this. As BBS routes are contingent upon observations proximal to roads, and that observers are constrained by aural and visual cues, these data

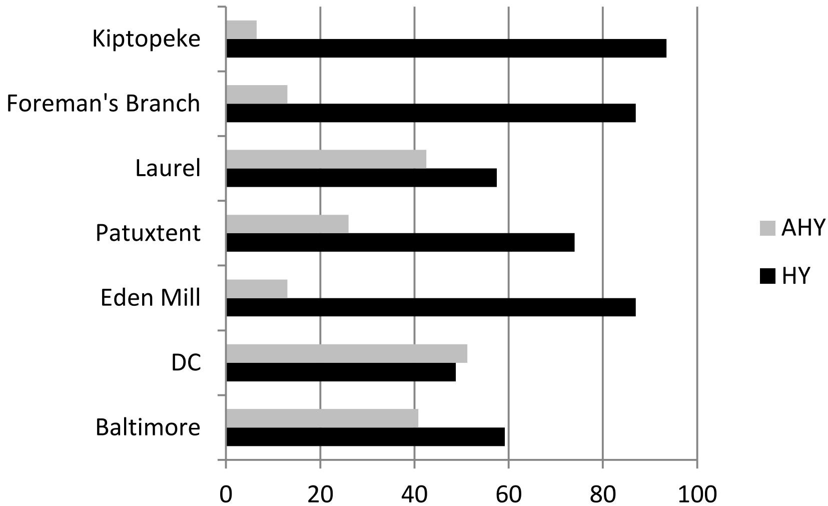

Figure 2. Percentages of After Hatching Year (AHY) and Hatching Year (HY) birds. Collected (Baltimore and DC) or banded (other banding stations) during fall migration from August through November in 2010 and 2011 in the Maryland/Virginia Piedmont (Eden Mill, Laurel, and Patuxent) and Coastal Plain (Foreman's Branch and Kiptopeke) (Robbins 2012). Mean values were used to represent data for both years.

can be variable and may not consider trends in some species where either proximity to roads or variation due to observer error is considerable. In the case of building collisions at night, these data may represent the attractiveness of the threat where observations include individuals that were actually handled and measured. Additionally, their evaluation is correlational at best, and does not provide data that could make a cause and effect determination (Shaub et al. 2011); other shortcomings were also suggested (Klem et al. 2012). Regardless, the magnitude of the difference in the proportions of first-year and older birds from collision mortality and those from regional banding stations are considerable, suggesting a greater importance of this threat to populations than previously considered.

ACKNOWLEDGMENTS

The authors would like to thank Wendy B. Olsson (Founder and former Coordinator, Lights Out Baltimore, Baltimore Bird Club, A Chapter of the Maryland Ornithological Society, Baltimore, Maryland), and Anne M. Lewis (President, Board of Directors, City Wildlife, Washington, District of Columbia) and Lisbeth S. Fuisz (Director, Lights Out DC, City Wildlife) for welcoming us into their homes and allowing us to participate in this effort. We thank James Tate, Jr. (Board of Directors, City Wildlife) for his assistance in processing the birds from the DC locations, and all of the volunteers from both organizations for their tireless efforts in collecting birds in Baltimore and DC during the early morning hours of migration. We also thank Suzanne A. Procell (Volunteer Bander, Eden Mill Nature Center) for data recording and Shane A. Hall for statistical assistance. We gratefully acknowledge and thank Daniel Klem, Jr. (Professor of Biology, and Sarkis Acopian Professor of Ornithology and Conservation Biology, Muhlenberg College, Allentown, Pennsylvania) and an anonymous reviewer for their insight and recommendations.

LITERATURE CITED

Arnold, T.W., and R.M. Zink. 2011. Collision mortality has no discernible effect on population trends of North American birds. *PLoS ONE* 6(9): e24708. doi:10.1371/journal.pone.0024708. Available at: http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0024708#pone-0024708-g002. Accessed: 24 March 2015.

Banks, R.C. 1979. *Human Related Mortality of Birds in the United States*. United States Department of the Interior, Fish and Wildlife Service, Special Scientific Report – Wildlife 215. 16 pp.

Darley, J.A., D.M. Scott, and N.K. Taylor. 1977. Effects of age, sex, and breeding success on site fidelity of Gray Catbirds. *Bird-Banding* 48(2):145-151.

Dunn, E.H. 1993. Bird mortality from striking residential windows in winter. *Journal of Field Ornithology* 64(3):302-309.

Evans Ogden, L.J. 1996. *Collision Course: The Hazards of Lighted Structures and Windows to Migrating Birds*. Special Report for the World Wildlife Fund Canada and the Fatal Light Awareness Program. 46 pp.

Gauthreaux, S.A., Jr., and C.G. Belser. 2006. Effects of artificial night lighting on migrating birds. Pages 67-93 in: C. Rich and T. Longcore (Editors), *Ecological Consequences of Artificial Night Lighting*. Island Press, Washington, DC. 480 pp.

Holmes, R.T., T.W. Sherry, P.P. Marra, and K.E. Petit. 1992. Multiple brooding and productivity of a Neotropical migrant, the Black-throated Blue Warbler (*Dendroica caerulescens*), in an unfragmented forest. *The Auk* 109(2):321-333.

Jones, J., and C.M. Francis. 2003. The effects of light characteristics on avian mortality at lighthouses. *Journal of Avian Biology* 34(4):328-333.

Klem, D., Jr. 1990. Collisions between birds and windows: mortality and prevention. *Journal of Field Ornithology* 61(1):120-128.

Klem D., Jr. 2009. How green are "green buildings"? *BirdScope* 23(4):11.

Klem, D., Jr. 2010. Avian mortality at windows: The second largest human source of bird mortality on earth. *Proceedings of the Fourth International Partners in Flight Conference: Tundra to Tropics*. Pages 244-251.

Klem, D., Jr., K.L. De Groot, E.A. Krebs, K.T. Fort, S.B. Elbin, and A. Prince. 2012. A second critique of 'Collision mortality has no discernible effect on population trends of North American birds' [*PLoS ONE* 6(9): e24708]. *PLoS ONE*: Reader Comments. Available at: http://www.plosone.org/annotation/listThread.action?root=49197. Accessed: 24 March 2015.

Longcore, T., C. Rich, P. Mineau, B. MacDonald, D.G. Bert, L.M. Sullivan, E. Mutrie, S.A. Gauthreaux, Jr, M.L. Avery, R.L. Crawford, A.M. Manville II, E.R. Travis, and D. Drake. 2012. An estimate of avian mortality at communication towers in the United States and Canada. *PLoS ONE* 7(4): e34025. doi:10.1371/journal.pone.0034025. Available at: http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0034025. Accessed: 24 March 2015.

Loss, S.R., T. Will, and P.P. Marra. 2013. The impact of free-ranging domestic cats on wildlife of the United States. *Nature Communications* 4(1396). DOI:10.1038/ncomms2380.

Loss, S.R., T. Will, S.S. Loss, and P.P. Marra. 2014. Bird-building collisions in the United States: Estimates of annual mortality and species vulnerability. *The Condor: Ornithological Applications* 116(1):8-23.

Lozano, G.A., and R.E. Lemon. 1999. Effects of prior residence and age on breeding performance in Yellow Warblers. *Wilson Bulletin* 111(3):381-388.

Manville, A.M., II. 2005. Bird strikes and electrocutions at power lines, communication towers, and wind turbines: State of the art and state of the science – next steps toward mitigation. Pages 1051-1064 in: C.J. Ralph and T.D. Rich (Editors), *Bird Conservation Implementation in the Americas: Proceedings of the Third International Partners in Flight Conference 2002 March 20-24; Asilomar, California, Volume 1 and 2*. United States

Department of Agriculture, Forest Service General Technical Report PSW-GTR-191, Pacific Southwest Research Station, Albany, CA. 1294 pp.

Martin, F.W. 1964. Woodcock age and sex determination from wings. *Journal of Wildlife Management* 28(2):287-293.

Martin, K. 1995. Patterns and mechanisms for age-dependent reproduction and survival in birds. *American Zoologist* 35(4):340-348.

McDonald, D.B., and H. Caswell. 1993. Matrix methods for avian demography. Pages 139-185 in: D.M. Power (Editor), *Current Ornithology, Volume 10*. Plenum Press, New York, NY. 398 pp.

Pyle, P. 1997. *Identification Guide to North American Birds, Part 1: Columbidae to Ploceidae*. Slate Creek Press, Bolinas, CA. 732 pp.

Robbins, C.S. 2011. Atlantic flyway review: Region IV Piedmont-Coastal Plain, fall 2010. *North American Bird Bander* 36(2):80-88.

Robbins, C.S. 2012. Atlantic flyway review: Region IV Piedmont-Coastal Plain, fall 2011. *North American Bird Bander* 37(2):74-83.

Roth, R.R, M.S. Johnson, and T.J. Underwood. 1996. Wood Thrush (*Hylocichla mustelina*). In: A. Poole and F. Gill (Editors), *The Birds of North America*, No. 246. The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists Union, Washington. DC.

Saether, B.E. 1990. Age specific variation in reproductive performance of birds. Pages 251-283 in: D.M. Power (Editor), *Current Ornithology, Volume 7*. Plenum Press, New York, NY. 388 pp.

Shaub, M., M. Kéry, P. Korner, and F. Korner-Nievergelt. 2011. A critique of 'Collision mortality has no discernible effect on population trends of North American birds' [*PLoS ONE* 6(9): e24708]. *PLoS ONE*: Reader Comments. Available at: http://www.plosone.org/annotation/listThread.action?root=9659. Accessed: 24 March 2015.

Sherry, T.W., and R.T. Holmes. 1995. Summer versus winter limitation of populations: what are the issues and what is the evidence? Pages 85-120 in: T.E. Martin and D.M. Finch (Editors), *Ecology and Management of Neotropical Migratory Birds: a Synthesis and Review of Critical Issues*. Oxford University Press, New York, NY. 489 pp.