B A N I S T E R I A

A JOURNAL DEVOTED TO THE NATURAL HISTORY OF VIRGINIA

ISSN 1066-0712

Published by the Virginia Natural History Society

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Banisteria 56: 18–24

RESEARCH ARTICLE

TECHNIQUES AND TRENDS IN AGING CARCASSES OF BIRD-WINDOW COLLISIONS IN THE NEW RIVER VALLEY

SAVANNAH L. LANCASTER[1], REBECCA SALEN[1], E. HALEY OLSEN-HODGES[2], SAM R. SIMON[2], AND KAREN E. POWERS [1]

1 *Biology Department, Radford University, Radford, Virginia 24142, USA* **2** *Department of Fish and Wildlife Conservation, Virginia Tech, Blacksburg, Virginia 24060, USA*

Corresponding author: Karen E. Powers (*kpowers4@radford.edu*)

Editor: T. Fredericksen | Received 30 May 2022 | Accepted 13 July 2022 | Published 14 July 2022

https://virginianaturalhistorysociety.com/banisteria/banisteria.htm#ban56

Citation: Lancaster, S. L., R. Salen, E. H. Olsen-Hodges, S. R. Simon, and K. E. Powers. 2022. Techniques and trends in aging carcasses of bird-window collisions in the New River Valley. Banisteria 56: 18–24.

ABSTRACT

Window collisions are a common cause of avian death during fall migration. Previous research has yet to reach a consensus whether naive migrants (i.e., young-of-the-year or hatch-year [HY] individuals) are more likely to collide with windows than adults (i.e., after-hatch-year [AHY]). We examined trends for 94 individuals collected during fall months in which HY birds are distinguished from AHY birds through feather color, patterns, and wear. We also used skull ossification via x-rays to confirm age category for a subset of our confidently-aged carcasses (N=38 individuals, 100% confirmation rate) or when our aging classification was uncertain (N=2). Across both techniques, we aged 94 birds of 37 species collected as window collisions at Radford University and Virginia Tech. We identified 82.9% as HY, which is slightly higher than expected by chance, but not statistically significant. We emphasize the value of aging techniques in future mitigation strategies and the novelty of using x-rays in bird-window collision studies.

Keywords: after-hatch-year, feather color, feather wear, hatch-year, skull ossification, x-ray.

INTRODUCTION

A major cause of bird mortality is window collisions, with estimates of up to 1 billion birds/year dying from collisions in North America (Klem, 2021). Reasons why birds collide with anthropogenic structures are many, but a primary reason is that birds cannot clearly differentiate vegetation and sky from reflections in glass (e.g., Klem, 1989). The risk of this type of collision is often heightened by near-building vegetation (i.e., perches and sources of cover) reflecting in the glass (Loss et al., 2019; Powers et al., 2022). Secondly, nocturnal migrants may simply not see the structures, as collisions with radio towers, wind turbines, or other unlit structures have been quantified (Drewitt & Langston, 2008).

The chance of collisions with glass may be affected by the age of the bird. Naive fall migrants (also known as hatch-years [HY], those born in the preceding summer months) might be more susceptible to colliding with windows. While adults (after-hatch-years [AHY]) have experience with their migratory path and the structures and stopover points along the route, HY birds lack this knowledge. Indeed, Hager et al. (2013) reported a greater number of HY mortalities than those classified as AHY in summer (75% were HY) and fall (57% HY) due to these collisions. However, the small sample size (N=22) tallied across both seasons limits extrapolation. Similarly, Klem (1989) examined differences in BWCs between age classes in fall months (September – December), when he assumed 75% of birds were HY; although he, too, had a small sample size (N=72) and geographic range (southern Illinois), he found that HY and AHY were colliding with windows in this same 3:1 ratio. This HY mortality is suggested through marked seasonal declines, and supported by 50 years of netting and banding data of ca. 500,000 individuals at Powdermill Nature Reserve (Westmoreland Co., Pennsylvania; Carnegie Institute, 2008); in fall months, HY birds comprise ca. 65% of fall migratory birds across all species, versus the following spring, when HY birds make up just 50% of captures (L. DeGroote, Powdermill Nature Reserve, pers. comm.). Given our focus on the fall migration months, Powdermill's substantial dataset suggests that at least 65% of birds passing through our Virginia study area were HY individuals. However, for statistical analyses, we conservatively followed Klem's (1989) research, assuming a 75% HY avian community structure from September – December.

The New River Valley in the Ridge and Valley province of western Virginia is a recognized migratory flyway (VDWR, 2022) as birds may navigate along the New River. This river directly borders the campus of Radford University (RU; City of Radford, Virginia) and is just 7.5 km west of Virginia Tech (VT; Montgomery Co., Virginia). Both of these campuses have initiated long-term bird-window collision surveying efforts (Radford University since 2018, Virginia Tech since 2019) and store carcasses from those projects as museum specimens, frozen carcasses, or artifacts. During the fall migratory period (here, defined as August 15 - December 15), HY birds often can be differentiated from AHY individuals through plumage molt patterns (i.e., feather wear) and feather color (Pyle, 1997). Given the availability of taxidermied specimens and frozen carcasses from both campuses, and the higher rate of collisions documented in fall migration months, we examined age patterns in collision rates. We hypothesized that at least 75% of our mortalities would be classified as HY, due to their commonality on the landscape and presumed naivety during the fall migration.

METHODS

Study Site

We collected bird-window collision mortalities across two campuses in the Ridge and Valley province, Virginia. Radford University (37° 8'15.468" N, 80° 33' 2.376" W; elevation 640 m) is an 82.5-ha public university situated along the New River. A suburban campus, surrounding land use includes the city of Radford, with student and single-family housing transitioning to a rural-dominated landscape. Most campus buildings are 4 stories tall. Virginia Tech (37° 13' 39.1" N, 80° 25' 20.3" W; elevation 618 m) is a 1050-ha public university in the New River Valley, located 15.3 km NE of Radford University. The campus is predominantly suburban, but includes a 4.5-ha mature forest stand and an adjacent single-runway airport. Virginia Tech is buffered to the west by agricultural land and to the east by the suburban town of Blacksburg. Most buildings on this campus are 2 to 5 stories tall.

Field and Laboratory Methods

Following Hager & Consentino (2014), and further detailed by Powers et al. (2019), students surveyed 15 campus buildings once or twice daily (7-14 visits/week) around Radford University and 45 campus buildings (1-5 visits/week) around Virginia Tech. Generally, students looked for injured or mortally-wounded birds within 2 m of building walls, walking the entire perimeter of these buildings from August 15 to the last week in November, and then collected birds sporadically through 15 December. At Radford University, this protocol was completed for four fall migrations, from 2018-2021, although opportunistic collections include those beginning in October 2013. At Virginia Tech, this protocol was completed for three fall migrations, 2019-2021.

We aged birds as HY or AHY using plumage color and/or wear characteristics. Pyle (1997) detailed species-specific features to age each individual. In general, blander color schemes and the presence of worn juvenile feathers that had not been regrown since fledgling stage were clues to HY status. Adult coloration and newly-replaced feathers presented features of AHY birds (Fig. 1).

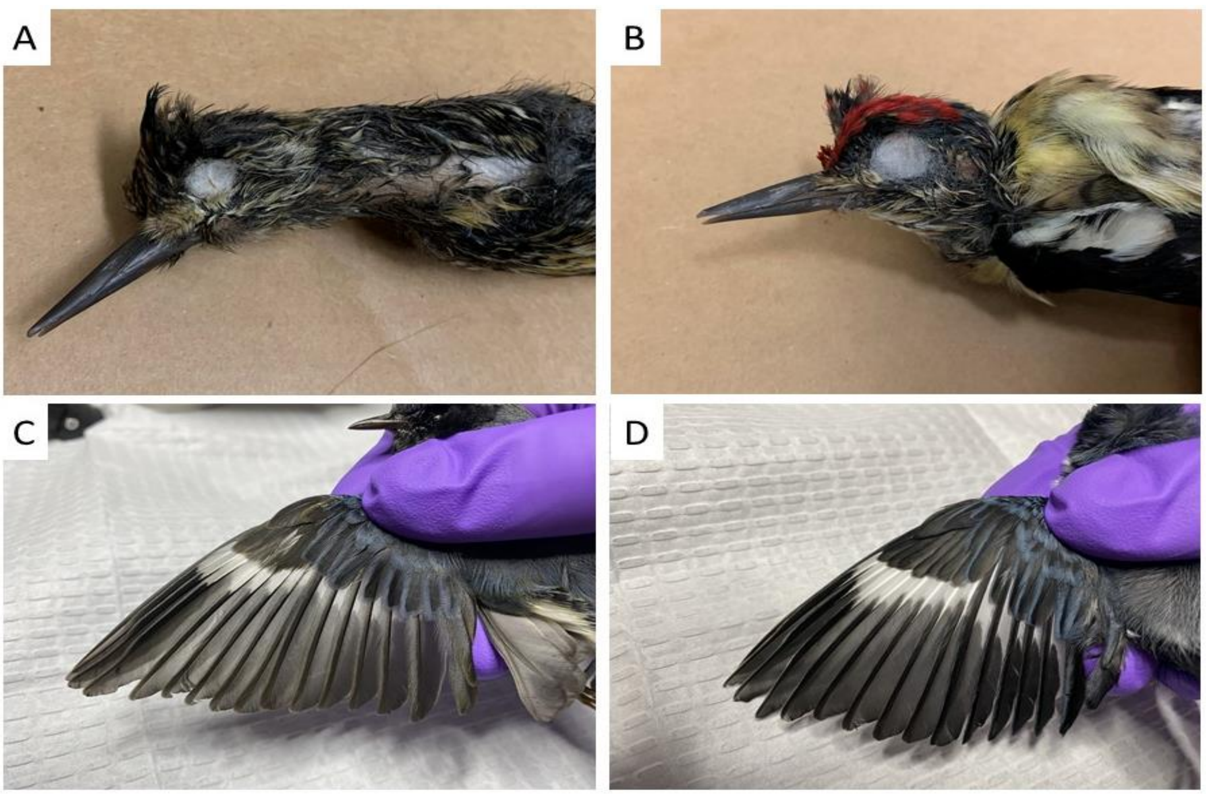

Figure 1. Examples of bird-window collision specimens that were categorically aged via feather differences: two taxidermied Yellow-bellied Sapsuckers (*Sphyrapicus varius*) from Radford University, aged as (A) hatch-year (HY) and (B) after-hatch-year (AHY) via differences in head feather color; two thawed Black-throated Blue Warblers (*Setophaga caerulescens*) from Virginia Tech, aged as (C) HY and (D) AHY via differences in wing feather wear.

The degree of ossification of the skull is a proxy for age in birds; ossification increases throughout the first year, and is generally completed by a bird's second summer. Because all of our specimens were collected in the fall, we assumed that a completely-ossified skull indicated an AHY bird. We tested our morphological aging for a subset of our collection (ca. 40% of our whole-bodied specimens) using skull x-rays (Linear MC-150, Progeny, Inc., Buffalo Grove, IL). In selecting our specimens for x-rays, half of the x-rayed specimens included representative passerines, 25% were from a single species with >10 carcasses, and 25% were less common warbler species whose plumage is considered "confusing" during fall months (Peterson, 2020). Among those x-rayed were two specimens whose age could not be definitively determined by plumage details (Fig. 2).

Once birds were confidently categorized as HY or AHY, we used a Pearson's chi-square test to examine whether the proportion of HY in our sample significantly exceeded 75% (Klem's [1989] expected proportion of HY on the landscape in fall months).

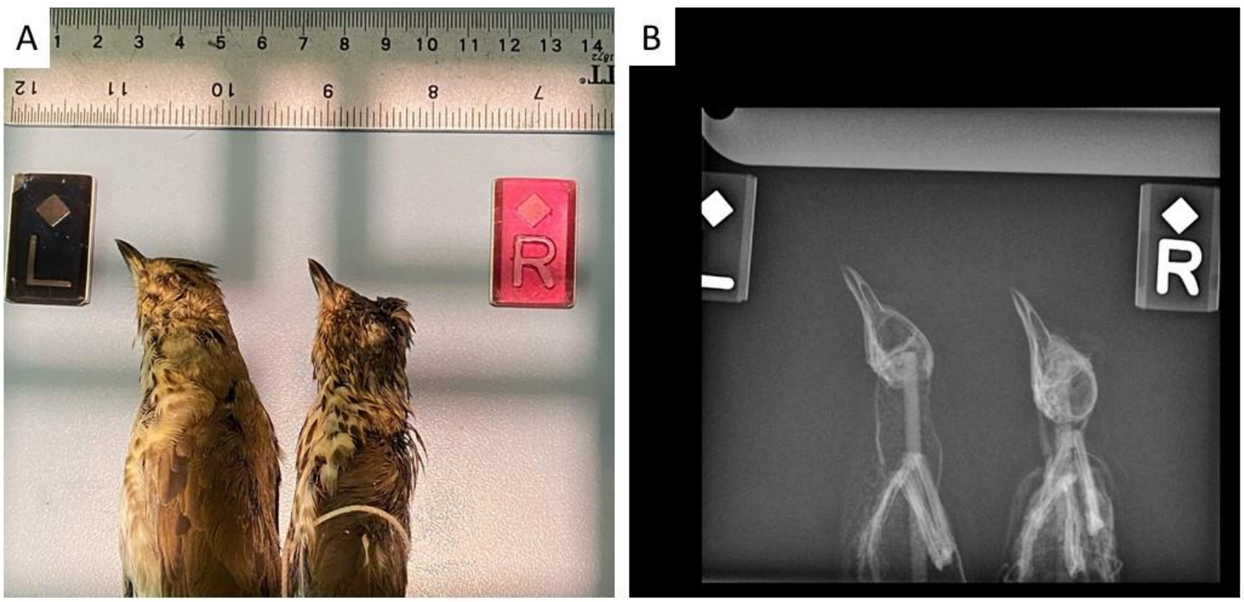

Figure 2. Pair of taxidermied Swainson's Thrushes (*Catharus ustulatus*), shown as (A) prepared mounts and (B) in an x-ray. The individual to the left is a hatch-year (HY), while that to the right is an after-hatch-year (AHY). Visible on the x-ray is a difference in skull bone density, although the wooden dowel in the HY individual obscures the clarity. The AHY is further ossified than the HY, as indicated by a relatively greater proportion of white on the skull x-ray.

RESULTS

Across both campuses, we collected 96 birds of 37 species: 32 spp. in order Passeriformes, 2 spp. in order Apodiformes, 1 sp. each in order Piciformes, Cuculiformes, and Columbiformes. We took x-rays of 40 representative individuals that included a range of passerine species (N=20), with additional focus on Swainson's Thrushes (*Catharus ustulatus*; N=10) and representative warblers from the genus *Setophaga* (N=10).

Of the 96 birds examined across both campuses, 92 were confidently aged via feather color and feather wear, and x-rays of 38 of these specimens confirmed our classifications. Two additional specimens (Nashville Warbler [*Leiothlypis ruficapilla*], Pine Warbler [*Setophaga pinus*]) that were tentatively aged as HY were confirmed by skull ossification in x-rays. The remaining two birds - both Brown Creepers, *Certhia americana* - could not be confidently aged via either method (Pyle [1997] noted creepers cannot be reliably aged once they lose juvenal plumage) and were classified as undetermined. Of the 94 that were aged, 78 (82.9%) were HY, and 16 were AHY (Table 1). In comparing this to the expected proportion of HY on the landscape (75%), a Pearson's chi-square test found that we documented slightly more hatch-year mortalities than by chance alone ($\chi^2 = 3.191$ df = 1, p = 0.074), but this trend was not statistically significant.

Table 1. List of 96 birds that were aged as hatch-year or after-hatch-year individuals as part of an on-going bird-window collision study at Radford University (Radford, Virginia) and Virginia Tech (Blacksburg, Virginia). Bird casualties collected during fall migration in 2013 and from 2018 – 2021.

	Radford University	Virginia Tech	Total Birds
Undetermined	1	1	2
Hatch-year	54	24	78
After-hatch-year	13	3	16
Total Birds	**68**	**28**	**96**

Discussion

Our discovery of 82.9% of bird-window collision casualties as HY suggests slightly but not significantly higher-than-expected mortalities by this naive age class. Klem (1989) found 75% of all species examined in fall months (September – December) were HY, while Hager et al. (2013) reported 81% of the carcasses recovered at buildings across both summer (start-date: 16 June) and fall were hatch-years. Our results may reflect our slightly earlier start-date than Klem (1989), suggesting that proportions of HY and AHY collision victims match what's on the landscape.

Long-term banding data from Powdermill Nature Reserve in Pennsylvania suggest approximately 23% hatch-year mortality rates during their first winter (L. DeGroote, pers. comm.). However, there is a lack of research surrounding the specific causes of HY mortality during this time frame. Several studies suggest that general unfamiliarity of young birds with their surroundings leads to higher mortality rates, with explanations including undeveloped navigation skills (Holland & Helm, 2013), increased chance of predation (Brown & Taylor, 2015), and anthropogenic factors like building collisions (Jenkins et al., 2010). Naivety likely plays a role in window collisions. However, with such a wide array of potential sources of mortality, it is hard to draw conclusions on drivers behind large-scale age mortality trends. Future studies should focus on elucidating causes for HY mortality during fall migration.

If we assume that window collisions constitute a substantial source of mortality for both adult and young birds, then mitigation efforts may be incorporated into long-term management goals. Increasing HY survivorship may be an important management goal, especially in light of decades-long bird losses throughout North America (Rosenberg et al., 2019). While we do not have the capability to "fix" the naivety of young birds, we can address these lethal bird-window collisions on both the Radford University and Virginia Tech campuses. Both locations should add commercially-available bird-deterring film on existing glass that is multi-level, contiguous, and large-paned (Klem, 2021).

In addition to providing fodder to university administrators to mitigate BWCs on our campuses, we also emphasize one key novel component of our research: the use of x-rays to confirm or fail to confirm age class for known or questionable individuals. Veltri & Klem (2005) used x-rays in order to assess and document skeletal damage in wind turbine and window-collision carcasses. However, they made no effort to age carcasses in this way. We believe that the use of x-rays to age specimens is a novel approach in the bird-window collision research realm. If used on a large scale, this method has potential to provide quick insight into the demographics of collision victims and minimize the need to spend hours sifting through technical plumage descriptions. In our investigation of 40 of our 96 specimens, all 40 x-rayed individuals confirmed our known or tentative age classes. Although a novel accessory method in aging birds, we do acknowledge limitations – we are most confident in x-ray determinations if HY and AHY individuals are already documented for conspecifics. Our relatively large representation of Swainson's Thrushes in this study confirmed such confidences. This x-ray comparison may work across species, but we are not aware of studies comparing differences in skull ossification rates across species. Larger conspecific sample sizes can help us elucidate subtle differences within and between age classes and also between frozen and taxidermied specimens. We intend to continue testing this method of aging as we collect additional collision victims. Further, due to scarcity of published HY versus AHY migratory information available on a large scale, our study is an important contribution to the avian research community.

ACKNOWLEDGEMENTS

We thank the >70 students between Radford University and Virginia Tech for collecting bird-window collision victims. We thank the Biology Department of Radford University, the Department of Fish and Wildlife Conservation at Virginia Tech, and the Office of Undergraduate Research and Scholarship (OURS) of Radford University. The Southwest Virginia Wildlife Center of Roanoke permitted the use of their x-ray machine for this study.

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