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BIRD MORTALITY FROM STRIKING RESIDENTIAL WINDOWS IN WINTER

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Abstract.—A continent-wide survey of bird mortality in one winter at 5500 homes where birds are fed elicited reports of one or more bird deaths from 1165 people. In the sample of respondents, 0.85 birds/house/winter died through striking windows. This figure is probably high because the people sampled were avid bird-feeders who attract birds close to windows. On the other hand, many cases of window strike deaths probably go unnoticed. Taking such considerations into account, the data support a previous estimate of 1–10 birds killed annually for every building in North America. Birds died from window strikes approximately in proportion to their abundance at feeders, and panic flights were implicated in a large proportion of strikes. The best proven solution is screening of windows.

MORTALIDAD DE AVES OCASIONADA POR CHOQUES CON VENTANAS DURANTE EL INVIERNO

Sinopsis.—Se hizo una encuesta a través de todos los Estados Unidos, en relación con la mortalidad de aves durante un invierno en residencias con comederos artificiales. De 5500 casas encuestadas 1165 personas indicaron al menos una muerte. De la muestra de respuestas se recoge que 0.85 aves/casa/invierno murieron a causa de choques con ventanas de cristal. El resultado es probablemente alto debido a que las personas incluidas en el sondeo de la encuesta colocaron los comederos cerca de sus ventanas para poder observar a las aves. Por otro lado, muchos casos de mortalidad por colisiones probablemente pasaron desapercibidos. Los datos apoyan un estimado previo en donde se indica que 1–10 aves mueren anualmente por cada edificio en Norte América. Las aves mueren de choques contra las ventanas en proporción (aproximadamente) a su abundancia en comederos. Los vuelos súbitos causados por depredadores fueron responsables de una alta proporción de las coliciones. La mejor solución al problema es colocar cedazo en las ventanas.

The most careful estimate to date of bird mortality from collisions with windows is that of Klem (1990). He suggested that 1–10 birds are killed annually by each building in the U.S., for a total of 97.6–975.6 million birds per year.

A survey of bird mortality at 5500 residences in the winter of 1989–1990 provided an unprecedented sample that allowed an independent assessment of Klem's estimates.

METHODS

Participants in 'Project FeederWatch' were provided with special forms requesting reports of mortality of birds in their yards during the winter of 1989–1990, from any cause. The forms suggested details that could be reported, which for window-killed birds included species, date, time, compass orientation and size of window, whether interior window covers were drawn, and sun conditions. Further comments were invited.

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Project FeederWatch is a cooperative survey in which volunteers across North America record the peak number of each bird species seen at their feeders over a 1- or 2-d period every second week from November to April (see Dunn 1986 for details of the Ontario Bird Feeder Survey, which used essentially the same methods). The counting method gives minimum numbers of birds present, because many more of each species may visit over a 2-d period than can be seen all at one time. Bird observations and information on habitat and bird-feeding characteristics are recorded on computer-readable forms and are edited and analyzed by the Cornell Laboratory of Ornithology. FeederWatch participants are spread all across the populated portions of Canada and the U.S., with about three-quarters living in the east.

RESULTS

Of the 5500 Project FeederWatch participants who submitted bird observations for the winter of 1989–1990, 507 (9.2%) reported one or more deaths ascribed specifically to window strikes (total of 995 window kills). The average per home responding to the mortality survey (i.e., reporting mortality from any cause) was 0.85 birds killed over the 4-mo winter season. Six reports were of 10 or more deaths at a single home, with two houses accounting for 21 deaths each.

Most of the 66 species represented in the window strike sample were ones that are common at bird feeders (Table 1), and all have been reported using feeders at FeederWatch sites at least occasionally. The most frequently killed species died approximately in proportion to their abundance at feeders in the sample of homes that reported window kills (Table 1). There was a weak, but significant, relationship ($r = 0.13$, $P < 0.01$, $n = 417$) between number of birds killed by hitting windows at each house (all species combined) and total number of individuals of those species present at the same homes (as recorded by FeederWatch counts; see Methods). Correlations between deaths and numbers counted within individual species were strongest for the ones most commonly killed (Table 2), suggesting that larger samples might show the same relationship for all species. In 10 of the 12 species listed in Table 2, the numbers present at homes where deaths occurred were significantly greater than the numbers present at other homes (which also reported window deaths, but not of that species). Thus, high numbers present were implicated as a factor in window death rates in most species, even when correlation between numbers killed and numbers present was not significant.

Panic flights caused by raptors were specifically mentioned as a contributing factor in 16% of all reports of window strikes, and an additional 1.5% mentioned that victims had been startled by loud noises, passing cars, arrival of large species such as Blue Jays (*Cyanocitta cristata*) at bird feeders, or chases by conspecifics. Many further cases of temporary inattention on the part of the victim surely went unreported, because most observers were first alerted to a strike by the sound of an impact.

Fatal collisions occurred evenly throughout the months fully covered

TABLE 1. Birds killed at FeederWatch homes in winter, 1989–1990.

Species	% of identified window kills (n = 945)	% of birds at feeders where window kills were reported (n = 84)[1]
*Pine Siskin *Carduelis pinus*	16.9	12.5
*American Goldfinch *Carduelis tristis*	13.2	11.5
*Dark-eyed Junco *Junco hyemalis*	12.9	9.2
*Northern Cardinal *Cardinalis cardinalis*	8.8	3.3
*Mourning Dove *Zenaida macroura*	5.5	9.7
*House Finch *Carpodacus mexicanus*	5.1	10.1
*Purple Finch *Carpodacus purpureus*	4.1	1.7
*Evening Grosbeak *Coccothraustes vespertinus*	3.7	3.3
*Black-capped Chickadee *Parus atricapillus*	3.2	3.5
*Pine Grosbeak *Pinicola enucleator*	2.1	0.4
*White-throated Sparrow *Zonotricia albicollis*	1.9	1.7
*Common Redpoll *Carduelis flammea*	1.6	1.8
*Downy Woodpecker *Picoides pubescens*	1.5	1.4
*House Sparrow *Passer domesticus*	1.5	7.2
*Tufted Titmouse *Parus bicolor*	1.1	1.7
Hermit Thrush *Catharus guttatus*	1.1	<0.5[1]
Cedar Waxwing *Bombycilla cedrorum*	1.1	<0.5[1]
*Cassin's Finch *Carpodacus cassinii*	1.1	0.4
*Blue Jay *Cyanocitta cristata*	1.0	2.9
*American Robin *Turdus migratorius*	1.0	0.5
*Red-winged Blackbird *Agelaius phoeniceus*	0.6	1.5
*Chipping Sparrow *Spizella passerina*	0.3	1.3
*Common Grackle *Quiscalus quiscula*	0.3	2.0
*European Starling *Sturnus vulgaris*	0.1	3.1
42 other species[2]	<1.0	<1.0 each

[1] Percent of average Project FeederWatch counts for the winter, all species summed. (Summation included only those species in the table for which exact Project FeederWatch

by Project FeederWatch ($\chi^2 = 0.72$, $n = 770$, $P = 0.87$). Window deaths were spread evenly among three 2-hr time blocks from 0900 to 1500 ($\chi^2 = 1.68$, $n = 225$, $P = 0.43$), with fewer kills in the 2-h time blocks before and after ($\chi^2 = 35.00$, $n = 297$, $P < 0.001$). Reports came from all parts of the continent, in proportion to the number of FeederWatchers in each region.

Data on conditions at the time of window kills showed that deaths occurred under a variety of circumstances (Table 3). Without comparable data from homes (or windows) that did not cause any kills, however, we cannot determine whether particular conditions contributed to the chances of death. If windows were equally distributed on all sides of all houses, for example, then kills were more frequent than expected on south-facing windows ($\chi^2 = 41.25$, $P < 0.001$). The distribution of windows, however, especially large panes which probably cause more deaths, may be biased towards southerly exposures.

A comparison of homes with and without reported window kills is possible for certain habitat information and bird-feeding practices, because Project FeederWatch collects these data annually from all participants. Homes with reported kills were significantly more likely than those without to have more extensive feeding programs than average, to be in rural areas of low population density with woods or open water nearby, and to have well-vegetated yards; all factors that also cause more birds to be present (Dunn, unpubl. data).

DISCUSSION

This study confirms suggestions by Klem (1989) that the rate of window kills and the species involved are directly related to the numbers and

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numbers were available for 1989–1990. These are marked with asterisks. For other species counts were made as categories of abundance only, because the species were uncommon at feeders.

[2] Other species killed (and *n*): *American Tree Sparrow *Spizella arborea* (7), *Red-breasted Nuthatch *Sitta canadensis* (6), *White-crowned Sparrow *Zonotricia leucophrys* (6), Rosy Finch *Leucosticte arctoa* (6), Sharp-shinned Hawk *Accipiter striatus* (5), *Fox Sparrow *Passerella iliaca* (5), *Gambel's Quail *Callipepla gambelii* (4), Bohemian Waxwing *Bombycilla garrulus* (4), *Song Sparrow *Melospiza melodia* (4), *Golden-crowned Sparrow *Zonotricia atricapilla* (4), *Carolina Chickadee *Parus carolinensis* (3), *White-breasted Nuthatch *Sitta carolinensis* (3), Golden-crowned Kinglet *Regulus satrapa* (3), *Varied Thrush *Ixoreus naevius* (3), *Field Sparrow *Spizella pusilla* (3), Gray Partridge *Perdix perdix* (2), Ruffed Grouse *Bonasa umbellus* (2), Cooper's Hawk *Accipiter cooperii* (2), *Red-bellied Woodpecker *Melanerpes carolinus* (2), *Brown Creeper *Certhia americana* (2), Yellow-rumped Warbler *Dendroica coronata* (2), and one each of: *California Quail *Callipepla californica,* Montezuma Quail *Cyrtonyx montezumae,* Mountain Quail *Oreortyx pictus,* American Kestrel *Falco sparverius,* Band-tailed Pigeon *Columba fasciata,* *Rock Dove *Columba livia,* Common Ground Dove *Columbina passerina,* Anna's Hummingbird *Calypte anna,* Gila Woodpecker *Melanerpes uropygialis,* Yellow-bellied Sapsucker *Sphyrapicus varius,* *Hairy Woodpecker *Picoides villosus,* Northern Flicker *Colaptes auratus,* *Steller's Jay *Cyanocitta stelleri,* Plain Tit *Parus inornatus,* *Pygmy Nuthatch *Sitta pygmaea,* Eastern Bluebird *Sialia sialis,* Gray Catbird *Dumatella carolinensis,* Yellow Warbler *Dendroica petechia,* Pine Warbler *Dendroica pinus,* *Brown-headed Cowbird *Molothrus ater,* and White-winged Crossbill *Loxia leucoptera.*

TABLE 2. Relationships between numbers of birds killed by striking windows and average annual FeederWatch counts.

Species	# window strike deaths	# present in counts[1]	Correlation (r), and (P) between # killed and # present		# present where none of this species was killed[2]
			r	P	
Common Redpoll	12	23.1	0.036	(0.456)	6.8*
Pine Grosbeak	12	7.9	0.127	(0.347)	2.3**
House Sparrow	13	25.0	—[3]	—[3]	10.2
Evening Grosbeak	18	18.0	0.113	(0.328)	6.0**
Purple Finch	22	7.4	0.157	(0.242)	2.5**
Black-capped Chickadee	23	5.3	−0.035	(0.437)	4.3
House Finch	31	22.1	0.019	(0.459)	12.1**
Mourning Dove	43	15.6	−0.059	(0.353)	10.1
Northern Cardinal	47	8.3	0.251	(0.045)	3.3***
American Goldfinch	70	21.7	0.230	(0.028)	9.3***
Dark-eyed Junco	72	13.9	0.191	(0.054)	7.2***
Pine Siskin	82	27.8	0.351	(0.001)	9.2***

[1] At feeders with reported kills of that species.

[2] Only includes homes that reported at least one window kill of some other species. P value indicates difference between these numbers and birds present at homes where at least one of this species was killed (second column in table). * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$.

[3] Never more than one killed per home.

kinds of birds present in the vicinity of windows. At the individual species level, however, the data are unsuited to showing whether one species is more vulnerable to window kills than another. FeederWatch counts for each species are not equivalent indices of abundance, because only peak numbers seen at one time are recorded. Territorial species are therefore undercounted (relative to local population size) in comparison to flocking species. Moreover, certain species that rarely visit feeders are sometimes common in yards and also figure in the list of window kills (e.g., Hermit Thrush *Catharus guttatus,* Cedar Waxwing *Bombycilla cedrorum* and Pine Grosbeak *Pinicola enucleator*). In nearly every commonly-killed species, however, numbers present were higher where kills occurred than where they did not, regardless of the magnitude of FeederWatch counts (Table 2). This evidence suggests that window kills occurred more or less in proportion to the numbers of each species present in the vicinity of feeders.

Distribution of deaths throughout the day may also be a function of the number of birds present at different times. I have no data on bird numbers at feeders each hour, but other studies differed in window kill rates with time of day (Klem 1989), suggesting that time *per se* is probably not as important as variation in periods of high bird concentration.

The figure of 0.85 winter window strike deaths per home with mortality data from any cause is clearly not applicable to every residence. The figure is too low because many deaths must go entirely unnoticed. Un-

TABLE 3. Distribution of window kills according to condition of window, weather and bird feeders.

	% kills	*n*
Direction of window[1]		
North	23	610
East	24	
South	36	
West	18	
Size of window		
>2.25 m^2	59	665
1–2.25 m^2	33	
<1 m^2	8	
Sun shining on window?		
Yes	23	348
No	77	
Drapes closed?		
Yes	4	662
No	96	
Distance to nearest feeder		
<3 m	38	666
3–15 m	54	
>15 m	8	

[1] In-between directions were rarely reported.

solicited comments from 3% of respondents mentioned that dogs, cats and even squirrels and opossums quickly made off with dead or stunned birds.

On the other hand, there are several factors suggesting this figure is too high. The 0.85/birds/home/winter figure presented here is based on results from the 1165 people who reported mortality of any kind. The "non-respondents" in this study, however, were 4335 people who returned data from their FeederWatch observations despite reporting no mortality. Although the mortality survey was optional, the study group is highly interested and cooperative, and the likelihood is strong that most in fact had no cases of mortality to report.

Moreover, the FeederWatch homes may suffer higher window strike rates than expected at an "average" residence. FeederWatchers live predominantly in well-vegetated rural and rural-suburban areas, which are likely to have higher bird populations, and birds were purposely attracted close to windows. Although about 20% of North American householders are thought to feed birds on occasion (Filion et al. 1985, Shaw and Mangun 1984), only a small percentage feed at the level of FeederWatchers (who use, on average, 7.7 feeders apiece). Those who reported window kills in this study hosted a minimum of 84 birds at their feeders on each 2-d count period (Table 2).

Lastly, my figures may not be applicable to the whole year, because winter is probably the time when birds are most abundant near this

sample of homes. Two houses with severe window strike problems studied by Klem (1989) had approximately equal death rates during the migratory seasons and winter (when feeders were present), but summer collisions were rare. At more typical homes not surrounded by natural vegetation, however, kill rates during migration are probably lower.

To put my figure of 0.85 window kills/home/winter into perspective, we can make some highly speculative assumptions in order to estimate a range of reasonable values. To calculate a plausible maximum figure, for example, assume that: 1) an appropriate proportion of birds reported dead from "unknown causes" should be added to those reported dead from window kills (this raises the base figure to 1.15 birds/home/winter); 2) half of the homes failing to report any deaths also had this many window kills (bringing deaths for all 5500 FeederWatchers to 0.70/home/winter); 3) for every bird found, five were missed (3.50/home/winter); 4) the same number of birds were killed in every other season (10.50 birds/home/year); and 5) extrapolating to a broader population, people who do not feed birds in winter have ⅔ as many window strikes in a year as those who do. (Assuming that 20% of people regularly feed birds, this brings the total down to 7.70 birds/home/year.)

Considering sources of over-estimation, one might make a different set of assumptions to calculate a minimum figure: 1) no birds dying in this study of "unknown cause" were killed by hitting windows (0.85/home/winter); 2) 25% of non-reporting homes also had the same death rates (0.35 birds/home/winter for all 5500 FeederWatchers); 3) for every bird found, one more was missed (0.70/home/winter); 4) half as many birds were killed in other seasons (1.40/home/year); and 5) people in the broader population who do not feed birds in winter have one third as many window strikes in a year as those who do (bringing the total down to 0.65 birds/home/year).

One can of course speculate endlessly as to the most appropriate assumptions in an exercise such as this. Only further data collection can provide surer answers. Nonetheless, the range of theses values (0.65 to 7.70 window kills/home/year) suggests that Klem's (1990) estimated range of 1–10 birds/building/year is quite realistic, at least for residential areas.

Klem's figures lead to a total estimate of 97.6–975.6 million window strike deaths per year, far higher than an earlier surmise of 3.5 million per year by Banks (1979). To put these mortality figures in perspective, consider that fall bird populations in the U.S. have been estimated at 20 billion (American Ornithologists' Union 1975), so 0.5–5% of birds die annually by striking windows if we follow Klem (1990). Though a small proportion of total annual bird mortality, numbers lost to window kills are probably not trivial, and we should be doing our utmost to reduce the toll.

Commonly-used methods of prevention (hawk decals on windows, moving objects hung in front) did not reduce window strikes under experimental conditions (Klem 1990). If windows are reflecting vegetation, such

objects may be essentially invisible, and in panic flights, birds might simply avoid the object but not the entire window. Comments from four FeederWatchers stated that installation of plastic garden-protection netting about 25 cm from the window essentially solved their severe window-strike problems. (In one case, a mortality rate of up to seven birds daily was cut to nine over the entire winter.) Such netting can be mounted on a frame for easy installation, and can be removed in seasons when strikes are few. The mesh does not block views significantly.

Over 17% of window strikes were caused by panic flights. A far higher percentage of deaths may actually have involved such flights, because most observers were first alerted to a strike by the sound of an impact. This suggests another method of window strike prevention: observe normal escape patterns, then place bird attractants (feeders, water, plantings) such that panic flights lead birds away from problem windows, rather than towards them.

Klem (1990) recommended putting feeders close to windows (within 0.3 m), so that panic flights cannot generate fatal momentum before a strike. Given that window-strike deaths occurred more or less in proportion to bird numbers near the home, an alternative is to avoid drawing birds within window kill range, by placing all bird attractants far away from glass hazards. At present, however, we have no information on the distance that would be effective.

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