Ornitología Colombiana

Nota Breve

Decals prevent bird-window collisions at residences: a successful case study from Colombia

Calcomanías evitan colisiones de aves contra ventanas de residencias: estudio de un caso exitoso de Colombia

Natalia Ocampo-Peñuela[1], Lourdes Peñuela-Recio[2], Álvaro Ocampo-Durán[3]

[1]Nicholas School of the Environment, Duke University, Durham, NC, USA
[2] Fundación Horizonte Verde. Cumaral, Meta, Colombia
[3] Universidad de los Llanos, Villavicencio, Meta, Colombia
✉ ocamponata@gmail.com, horizonteverdelupe@gmail.com, aocampo@unillanos.edu.co

Abstract

Collisions with windows are responsible for one billion annual bird deaths in the United States alone, and are the second greatest cause of human-caused bird mortality. Although windows can be a significant threat to Neotropical birds, few studies have quantified collisions and none have targeted residences in this tropical region. Research in the United States and Canada has shown that residences are responsible for 44% and 90% of the window collisions, respectively. We studied bird-window collisions at a rural residence in a 4-hectare nature reserve located on the Eastern Andes piedmont in Colombia. Large and abundant windows provided attractive views but also resulted in frequent collision events, many of which were fatal. Between 2009 and 2012, we tested the effect of bird deterrent decals on collision reduction. After bird decal application on five windows (0.41 decals/m^2) collisions were reduced by 84% in 36.32m^2 total glass area. We show a successful case of residence-scale collision prevention to inspire other homes to stop bird mortality.

Key words: bird strike deterrence, decals, Eastern Andes foothills, human-made structures, nature reserve

Resumen

Las colisiones de aves contra ventanas son responsables por mil millones de muertes de aves anualmente en los Estados Unidos, y son la segunda mayor causa de muertes de aves causadas por humanos. Aunque las ventanas pueden ser una amenaza significativa para las aves Neotropicales, pocos estudios han cuantificado este problema y ninguno se ha enfocado en residencias en esta región tropical. Investigaciones en los Estados Unidos y Canadá muestran que las residencias son responsables por 44% y 90% de las colisiones contra ventanas, respectivamente. Nosotros estudiamos colisiones de aves contra ventanas en una residencia rural en una reserva natural de 4 hectáreas ubicada en el piedemonte de los Andes Orientales de Colombia. Grandes y abundantes ventanas proveían excelentes vistas pero también causaban colisiones frecuentemente, muchas de las cuales fueron fatales. Entre el 2009 y el 2012 probamos el efecto de calcomanías en la reducción de colisiones. Seguido a la aplicación de calcomanías en cinco ventanas (0.41 calcomanías/m^2) las colisiones se redujeron en un 84%. Aquí presentamos un caso exitoso de prevención de colisiones de aves contra ventanas en una escala de hogar para inspirar a otros a prevenir la mortalidad aviar.

Palabras clave: calcomanías, construcciones antropogénicas, disuasores de aves, piedemonte Cordillera Oriental, reserva natural

Introduction

Bird collisions with sheet glass in the form of windows are the second largest human source of bird mortality in the United States (Klem 2009a), after free-ranging domestic cats (Loss et al. 2013). Bird fatalities due to window collisions have been estimated at 365 million to one billion annually in the United States (Klem 1990, Loss *et al*. 2014). Birds behave as if windows are invisible to them, attempting to reach habitat seen through a clear glass, or reflected in mirrored panes (Klem 1989, O'Connell 2001). Various factors attract birds near to windows: feeders, immediate surrounding vegetation, bird baths or impoundments, nesting or perching sites, and protection from adverse weather. Building conditions, on the other hand, can make some structures more dangerous than others, including building location, amount of glass exposed to the environment and artificial lighting conditions (Klem 1989, Klem *et al.* 2004, Ocampo-Peñuela *et al.* 2016).

Although in the United States and Canada collisions have received some attention (Seewagen & Sheppard 2012, Lambertucci *et al.* 2015), this issue has not been consistently documented in the Neotropics. Two published bird-window collision studies in this region assess collisions on university campuses in Mexico (Cupul-Magaña 2003), and Colombia (Agudelo-Álvarez *et al.* 2010). Birds collide with windows in urban, suburban, and rural areas (Klem 1989). Rural residences, however, were found to have significantly more collisions than urban residences in a study in Canada (Bayne *et al.* 2012). At the national scale, 44% of documented collisions in the United States (Loss *et al.* 2014), and 90% of those in Canada (Machtans *et al.* 2013) happen at residences one to three stories tall. This could also be an issue in Colombia, where 24% of the human population lives in rural areas (Banco Mundial 2015) and suburban housing developments are increasing as people choose suburban over urban residences. Collisions are also an important threat to Neotropical migrants, especially during their journeys. In North America, studies have documented higher collision events during spring (April-May) and fall (September-October) migration (Taylor & Kershner 1986, O'Connell 2001, Hager *et al.* 2008, Ocampo-Peñuela *et al.* 2016). A study in Colombia's capital also noted this pattern (Agudelo-Álvarez *et al.* 2010).

Bird-window collisions can be easily prevented. Mitigation methods that can be used at residences include: vegetation reduction near windows, netting, angling windows down, UV-reflective glass, and closely spaced decals (Klem *et al.* 2004, Klem 2006, 2009a). UV-reflective films and decals have received special attention because these are visible to birds, but almost invisible to humans (Hausmann *et al.* 2003). Field experiments by Klem (2009b) showed that external films with a UV-reflecting component of 20–40% over 300–400 nm effectively deterred bird-window collisions. However, to date there is no field experiment at the building scale.

We tested the efficacy of commercially available bird deterrent decals on preventing bird-window collisions. Drawing from an existing baseline for collisions, we performed this experiment at a rural residence in a 4-hectare nature reserve located in the Eastern Andes piedmont in Colombia. We documented collisions from 2009 to 2012 before and after decal application. To our knowledge, this represents the first published study of bird-window collisions at a residence in the Neotropics.

Materials and methods

Study Area. - This study took place at the main residence of Kaliawirinae Nature Reserve (hereafter KNR), located in close proximity to the Guacavía river (4°17'13"N, 73°30'32"W) and 3 km from the town of Cumaral in Meta Department, Colombia (Fig 1). This 4 ha reserve features an array of microhabitats including shaded citrus plantations, multi-strata palm oil plantation, cattle pastures and riparian forest. Each microhabitat houses distinct bird communities (Ocampo-Peñuela 2006) accounting for a total of 154 species recorded to date, twelve of which are Neotropical migrants (Ocampo-Peñuela, unpublished data). The surrounding landscape is mostly deforested and used for small-scale agriculture and cattle ranching (Fig 1B). At 450 m above sea level, the climate is generally warm and humid and follows a unimodal rain pattern. KNR receives an average 4600 mm of

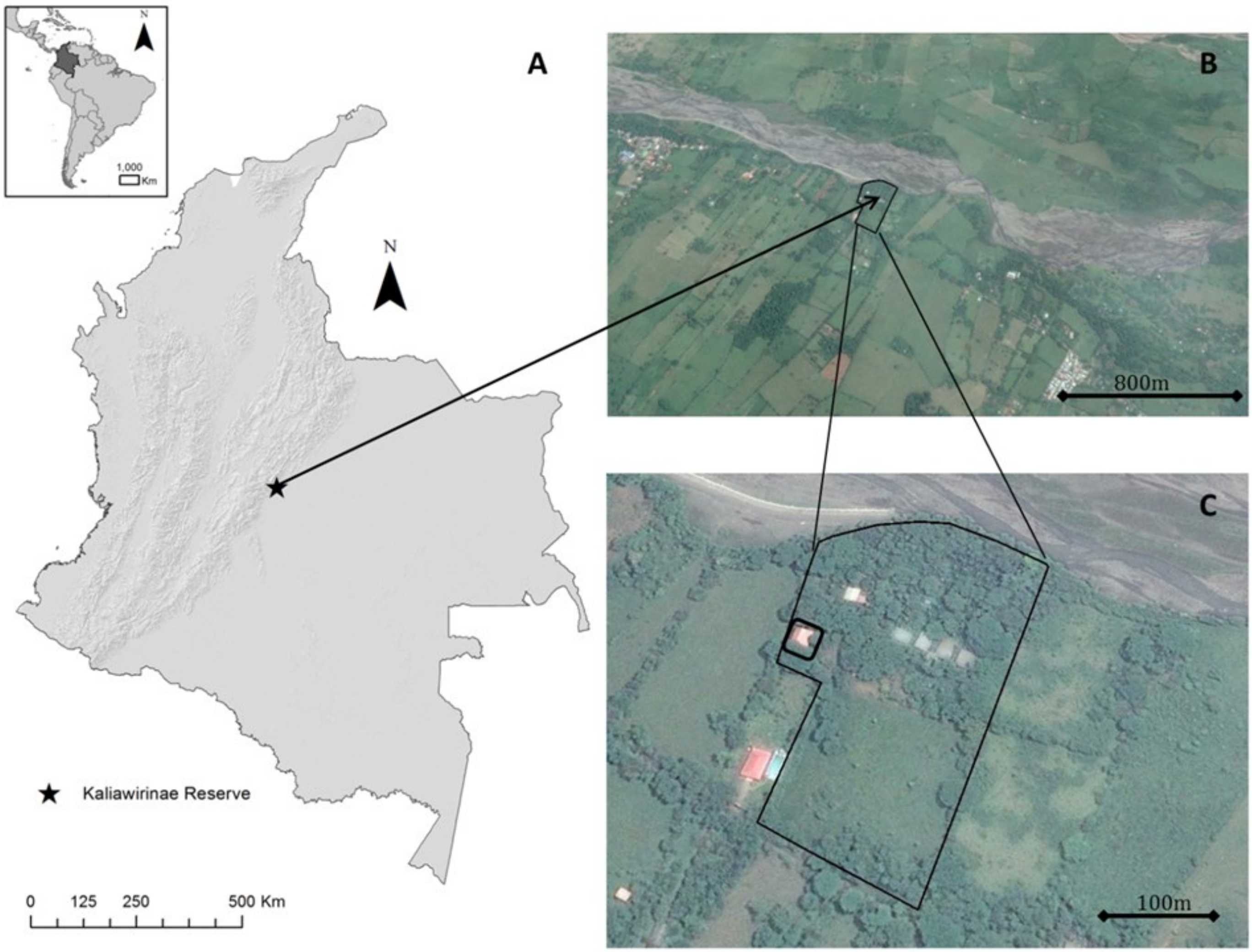

Figure 1. (A) Location of study area on a map of Colombia (B) Local landscape near KNR. (C) Kaliawirinae Nature Reserve with main residence highlighted by black square. Source for images B and C: Google Earth 2013.

rain annually, as recorded by our rain gauge (Ocampo, unpublished data). The main residence was finished in September 2008, and has an area of 270 m^2. It has 15 windows of different sizes and three double sliding doors that add up to 36.32 m^2 of glass. No bird feeders exist inside the reserve. However, flowering and fruiting trees were planted near and around the residence.

Decal treatment. - Between July 2009 and December 2012, we recorded all bird-window collision events at the study site. For each collision event we recorded: date, time of collision, status (dead/alive), and weather conditions (clear, cloudy, rainy). Although we did not use standardized collection methods, collision events were usually audible to resident inhabitants. Since these sound cues can be heard from anywhere in the small residence and there was always someone present, we were able to document a high proportion of the collision events.

From July 2009 to September 2011 all fifteen windows had no bird deterrent treatment. In September 2011, we applied 15 bird deterrent decals on five windows (0.41 decals/m^2). These divide the transparent space of windows and can be seen by birds, but are perceived as “frosting” by humans.

Decals were placed approximately 10 cm apart from each other as suggested by Klem (2006). The expected lifetime of decals is 6-9 months as indicated by the manufacturer (Window-Alert 2012), which claims that these are UV-reflective but provide no measure of the spectral UV strength or wavelength.

Data analyses. - In order to test the effectiveness of bird deterrent decals, we compared 15 months of collision data before decals (October 2009-December 2010) to the same months after decal installation (October 2011-December 2012). We ran a one-tailed paired t-test to compare these two data sets using R (R Core Team 2015). We also compared our residential collision data with the species inventory for KNR, with the other Colombian study by Agudelo-Álvarez *et al.* (2010), and with data available from the United States and Canada.

Results

Total collisions. - Between July 2009 and December 2012, we recorded 90 bird collisions of 25 identified species in 18 families (Table 1, following taxonomy by Remsen *et al.* (2014). This corresponded to 16% of the species thus far recorded at KNR. All species found as victims of collisions had previously been observed on the premises (Ocampo-Peñuela, unpublished data). We identified six individuals only to family level and left two unidentified.

In 52% of the cases, collisions were fatal and in these cases, we collected the carcasses and delivered them to either the Instituto de Ciencias Naturales of the Universidad Nacional de Colombia, or the Museo de Historia Natural in the Universidad de los Llanos in Villavicencio. For the remaining 48% of the events, we rehabilitated and released the birds. We did not band any birds, thus we were unable to monitor bird survival following release or detect whether the same individuals hit windows multiple times. Two species had ten or more collision events: Black-billed Thrush *(Turdus ignobilis)* and Palm Tanager *(Thraupis palmarum).* Four families had five or more collisions: Turdidae, Thraupidae, Picidae, and Columbidae (Table 1).

Before and after decals. - Before the installation of bird deterrent decals, an average of 3.15 collisions occurred per month. After the decal installation, the monthly average dropped by 84% to 0.5 collisions per month (Fig 2) and only one out of eight collisions occurred on a window with decals after their installation (Violaceus Jay, *Cyanocorax violaceus).* We found significant differences (one-tailed paired t test p=0.002) between monthly collisions before and after decals in a 15-month period.

Collisions occurred year-round but peaked during August and September. Collisions happened on clear and sunny days 71% of the time, 26% on overcast days, and 3% of the time on rainy, dark, or windy days. These events continued to occur after the decal application, but to a lesser extent. Of the cumulative collisions after the first decal application, 88% occurred on windows with no decals. The remaining 12% of collisions (1 event) occurred on a window with decals.

Discussion

We observed that, with the possible exception of one austral migrant, only resident birds collided with windows at KNR. The lack of migrants contrasts with results from Agudelo-Álvarez *et al.* (2010) in which 61% of the species and 77% of the collisions were migratory birds. In the study in Mexico, however, resident species also collided with windows more often than migrants (Cupul-Magaña 2003). Perhaps the incidence of an urban context can explain why the first study had more collisions by migrants. It is possible that migrants

Table 1. Bird species and number of collisions per species registered in bird collision study at Kaliawirinae Nature Reserve in Colombia from June 2009 to December 2012. Numbers in parenthesis indicate fatalities. Taxonomy follows Remsen *et al.* (2014). El símbolo (^) indicates a possible austral migrant. Only collision in windows with decals is indicated by the symbol (*) .

Family	English name	Species	# Collisions before decals	# Collisions after decals
Cracidae	Speckled Chachalaca	*Ortalis guttata*	1 (1)	
Columbidae	Scaled Dove	*Columbina squammata*	1 (1)	
	Ruddy Ground-Dove	*Columbina talpacoti*	3 (3)	
	Grey-fronted Dove	*Leptotila rufaxilla*	1 (1)	
Cuculidae	Dark-billed Cuckoo	*Coccyzus melacoryphus*^	2 (1)	
Strigidae	Tropical Screech-Owl	*Megascops choliba*	1 (1)	
Trochilidae	Glittering-throated Emerald	*Amazilia fimbriata*	1	
	Unidentified hummingbird		1	1
Alcedinidae	American Pygmy-Kingfisher	*Chloroceryle aenea*	1	
Ramphastidae	Chestnut-eared Araçari	*Pteroglossus castanotis*	3 (1)	
	Lettered Araçari	*Pteroglossus inscriptus*	1(1)	
Picidae	Spot-breasted Woodpecker	*Colaptes punctigula*	1	2
	Little Woodpecker	*Veniliornis passerinus*	2	
	Unidentified woodpecker		1	
Thamnophilidae	Unidentified antbird		1(1)	
Tyrannidae	Social Flycatcher	*Myiozetetes similis*	1(1)	
	Tropical Kingbird	*Tyrannus melancholicus*	2(1)	
Pipridae	White-bearded Manakin	*Manacus manacus*	1	
Tityridae	Black-tailed Tityra	*Tityra cayana*	2(1)	
Corvidae	Violaceous Jay	*Cyanocorax violaceus*		1*
Trogolodytidae	House Wren	*Troglodytes aedon*	3(1)	
Turdidae	Black-billed Thrush	*Turdus ignobilis*	29 (23)	2(2)
Thraupidae	Silver-beaked Tanager	*Ramphocelus carbo*	1	
	Blue-grey Tanager	*Thraupis episcopus*	7	
	Palm Tanager	*Thraupis palmarum*	10 (3)	
	Bananaquit	*Coereba flaveola*		1
Emberizidae	Saffron Finch	*Sicalis flaveola*	1(1)	
	Unidentified seedeater ♀	*Sporophila sp.*	1	
Icteridae	Yellow-rumped Cacique	*Cacicus cela*	1	1(1)
Unidentified birds	Small black bird		1	
	Small yellow and black bird		1(1)	
	TOTAL		82 (43)	8 (3)

have fewer and more concentrated habitats available in urban areas, while rural areas offer a larger extent and diversity of habitats.

There are no published studies on breeding birds in this area, but we have obtained breeding evidence for 17 out of the 25 species recorded in our collision study (Ocampo-Penuela, unpublished data). Some of the collision victims were fledglings, as was the case for two Araçaris *(Pteroglossus castanotis)* and a Spot-breasted Woodpecker *(Colaptes punctigula).* Sex, age, or residency status have no influence on collisions (Klem 1989), rather the abundance of individuals in different age classes affects collision results, as is the case for juveniles during fall migration (Hager *et al.* 2013). Mi-

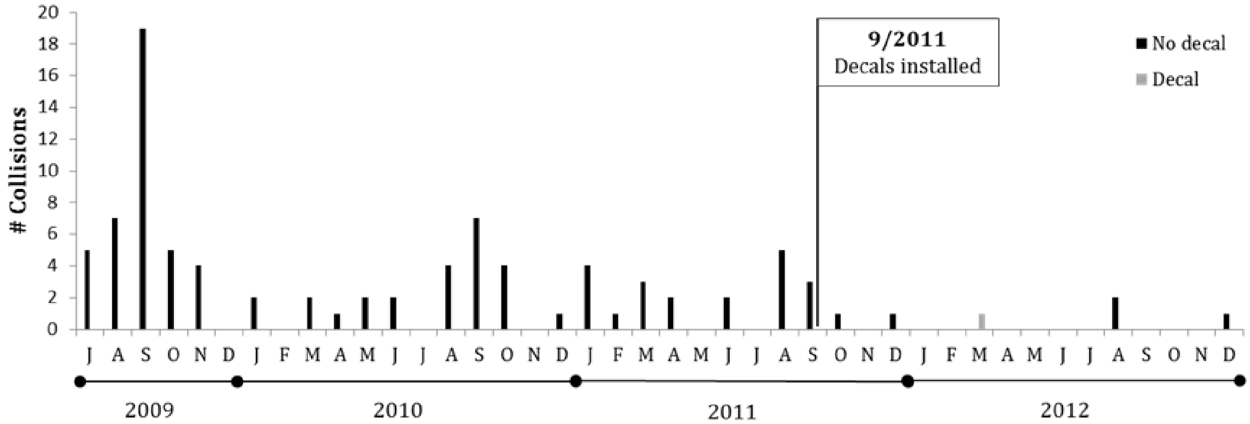

Figure 2. Monthly bird-window collision frequency from Kaliawirinae Nature Reserve before and after bird deterrent decal application from June 2009 to December 2012.

gratory birds are more prone to being attracted by lights of medium and high-rise buildings in cities during overcast conditions, and are then caught in a maze of glass and artificial lighting that increases their collision risk (Evans Ogden 1996). Resident birds are more often found as collision victims in 1-3 story residences (Loss *et al.* 2014). We found evidence for the latter, which is consistent with results from a study in Canada (Bayne *et al.* 2012).

In our study, 16% of the species recorded at KNR had collisions events. Similarly, a study in Illinois that coupled point counts with bird-window collisions found 22% of the recorded species to be collision victims (Hager *et al.* 2013). Black-billed Thrush and Palm Tanager had the highest collision frequencies in our study and are also among the species most commonly observed near the residence (Ocampo-Peñuela 2006), often frequenting semi-urban areas (Hilty & Brown 1986). The thrush is a species that prefers the understory and often flies low, a characteristic found to make species more prone to collisions (Klem 2014). The Palm Tanager is a species of shrubby areas, forest edges, and populated areas, but is mainly found in treetops (Hilty & Brown 1986). We think the presence of medium-height fruiting trees near the residence attracts both of these frugivorous species.

Species size in collision victims varied from very large (guans and toucans) to very small (hummingbirds) with no discernible pattern. This lack of pattern was also true for the probability of surviving after a strike.

The majority (71%) of collisions occurred on clear and sunny days, in concordance with results from Klem (1989), who found collisions occurred more frequently during favorable weather. Mortality due to collision was only 52%, compared to 88% in the Agudelo-Álvarez *et al.* (2010) study. We hypothesize that the resident species documented in our study move at lower speeds than migratory birds. Migrants enroute to or from their wintering grounds hit windows at very dangerous speeds and collisions are often fatal. The 12 species of migratory birds that frequent KNR spend the northern winter in the reserve and behave like residents. Their movements consist mostly of food searches, changing perches, and finding shelter from hostile weather. We suspect that this sedentary behaviour pattern prevents migrants from colliding with windows at our study site, compared to Bogota's university campus which probably lies on a migratory pathway (Agudelo-Álvarez *et al.* 2010). In addition, the more forested setting at KNR (Fig 1B) probably results in shorter distance flights between vegetation, as opposed to longer flights to find scarce vegetation patches in more urban settings.

The average monthly collisions at KNR before decal application (3.15) exceeded the 2.1 birds/year average calculated for residences in the United States by Loss *et al*. (2014). Higher collisions at KNR are likely explained by the high bird diversity found on the premises. The residence we studied is surrounded by one of the few forest remnants in the vicinity (Fig 1B), thus acting as an oasis for several bird species.

Previous field experiments by Klem (1990, 2009), indicated that covering windows with decals or other objects separated by 5 to 10 cm can be highly effective in preventing collisions. Our study confirms this and is, to our knowledge, the first to test decals in a residence in the Neotropics.

The added cost of making a residence bird friendly is low, considering the substantial benefits to birds. Four Window-Alert decals currently cost USD$7. We used 15 bird deterrent decals to cover 5 windows in our residence, and thus spent a total of USD$26. These specific decals call for annual replacement, but as technology progresses we might see permanent decals in the market. We present this as a very economic, effective, easy, unobtrusive, and commercially available solution for all households that have bird-window collision problems. The impact of preventing bird collisions on residences could be significant in contributing to bird safety. Future studies should focus on documenting collisions in a standardized way that allows for ease in understanding and replication at different scales and within a gradient of urban-to-rural landscapes. Several other variables could be quantified to further understand collision frequency, such as vegetation density and distance to windows, weather conditions and solar reflectance on windows. Another important contribution would be to band/mark collision victims that survive in order to understand probability of mortality and detect whether the same individuals collide with windows several times. We invite people all over the world to use decals to make their homes more bird-friendly, and contribute to the abatement of the second largest cause of bird mortality.

Final comments

The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008. The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional guides on the care and use of laboratory animals. This study is completely independent of the Window Alert Company and intends to show the use of commercially available bird deterrent solutions only, regardless of brand name.

Acknowledgements

We thank Patricia Escobar who helped gather collision information and rehabilitate birds that survived collision events, Gary Stiles and Juan Pablo López of the Universidad Nacional de Colombia and Jorge Enrique Avendaño of the Universidad de los Llanos for preparing and incorporating the specimens in the respective ornithological collections, and Laura Agudelo and Daniel Klem for comments and revisions to the manuscript.

Literature cited

Agudelo-Álvarez, L., J. Moreno-Velasquez, & N. Ocampo-Peñuela. 2010. Colisiones de aves contra ventanales en un campus universitario de Bogotá, Colombia. Ornitología Colombiana 10:3-10.

Banco Mundial. 2015. Indicadores de agricultura y desarrollo databank: Población rural 2010-2014. BIRF-AIF.

Bayne, E. M., C. A. Scobie,& M. Rawson-Clark. 2012. Factors influencing the annual risk of bird–window collisions at residential structures in Alberta, Canada. Wildlife Research 39:583-592.

Cupul-Magaña, F. G. 2003. Nota sobre colisiones de aves en las ventanas de edificios universitarios en Puerto Vallarta, México. Huitzil, Revista Mexicana de Ornitología 4:17-21.

EVANS OGDEN, L. J. 1996. Collision course: the hazards of lighted structures and windows to migrating birds. Fatal Light Awareness Program (FLAP), Ontario, Canada.

HAGER, S. B., B. J. COSENTINO, K. J. MCKAY, C. MONSON, W. ZUURDEEG & B. BLEVINS. 2013. Window area and development drive spatial variation in bird-window collisions in an urban landscape. Plos One 8:e53371.

HAGER, S. B., H. TRUDELL, K. J. MCKAY, S. M. CRANDALL& L. MAYER. 2008. Bird density and mortality at windows. The Wilson Journal of Ornithology 120:550-564.

HAUSMANN, F., K. E. ARNOLD, N. J. MARSHALL, & I. P. F. OWENS. 2003. Ultraviolet signals in birds are special. Proceedings of the Royal Society of London B 270:61-67.

HILTY, S. L., & B. BROWN. 1986. A guide to the birds of Colombia. Princeton University Press.

KLEM, D. 2006. Glass: a deadly conservation issue for birds. Bird Observer 34:73-81.

KLEM JR., D. 1989. Bird Window Collisions. The Wilson Bulletin 101:606-620.

KLEM JR., D. 1990. Collisions between Birds and windows: mortality and prevention. Journal of Field Ornithology 61: 120-128.

KLEM JR., D. 2009a. Avian mortality at windows: The second largest human source of bird mortality on earth. Pages 244–251 in Tundra to Tropics: Proceedings of the Fourth International Partners in Flight Conference (C. A. T. D. RICH, D. DEMAREST, AND C. THOMPSON, Ed.). Partners in Flight, McAllen, Texas, USA.

KLEM JR., D. 2009b. Preventing bird-window collisions. The Wilson Journal of Ornithology 121:314-321.

KLEM JR., D. 2014. Landscape, legal and biodiversity threats that windows pose to birds: A review of an important conservation issue. Land 3:351-361.

KLEM JR., D., D. C. KECK, K. L. MARTY, A. J. MILLER BALL, E. E. NICIU& C. T. PLATT. 2004. Effects of window angling, feeder placement, and scavengers on avian mortality at plate glass. The Wilson Bulletin 116:69-73.

LAMBERTUCCI, S. A., E. L. C. SHEPARD& R. P. WILSON. 2015. Human-wildlife conflicts in a crowded airspace. Science 348:502-504.

LOSS, S. R., T. WILL, S. S. LOSS& P. P. MARRA. 2014. Bird-building collisions in the United States: Estimates of annual mortality and species vulnerability. The Condor 116:8-23.

LOSS, S. R., T. WILL& P. P. MARRA. 2013. The impact of free-ranging domestic cats on wildlife of the United States. Nature communications 4:1396.

MACHTANS, C. S., C. WEDELES & E. M. BAYNE. 2013. A first estimate for canada of the number of birds killed by colliding with building windows. Avian Conservation and Ecology 8:6.

O'CONNELL, T. J. 2001. Avian window strike mortality at a suburban office park. The Raven 72:141-149.

OCAMPO-PEÑUELA, N. 2006. Comparación de la avifauna de tres sistemas de producción en los Llanos Orientales de Colombia. Revista Estudiantil de Investigación Ecotono Ecología Biológica y Social 4:6-14.

OCAMPO-PEÑUELA, N., R. S. WINTON, C. J. WU, E. ZAMBELLO, T. W. WITTIG, & N. L. CAGLE. 2016. Patterns of bird-window collisions inform mitigation on a university campus. PeerJ 4:e1652.

R CORE TEAM. 2015. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.

REMSEN, J. V., JR., C. D. CADENA, A. JARAMILLO, M. NORES, J. F. PACHECO, M. B. ROBBINS, F. G. STILES, D. F. STOTZ & K. J. ZIMMER. Version 30 october 2014. A classification of the bird species of South America. http//:www.museum.lsu.edu/~Remsen/SACC Baseline.html.

SEEWAGEN, C. L.& C. SHEPPARD. 2012. Bird Collisions with Windows: An Annotated Bibliography. American Bird Conservancy, The Plains, VA, USA.

TAYLOR, W. K., & M. A. KERSHNER. 1986. Migrant birds killed at the vehicle assembly building (VAB), John F. Kennedy Space Center. Journal of Field Ornithology: 142-154.

WINDOWALERT. 2012. WindowAlert decals. vol. 2014, http://www.windowalert.com/.

Recibido: 29 de junio 2015 *Aceptado:* 26 de febrero de 2016