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ARTICLE

Bird mortality due to collisions in glass panes on an Important Bird Area of southeastern Brazil

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ABSTRACT: Human-caused alterations to the environment are important causes of the loss of bird biodiversity globally. Collisions with windows are the second leading human cause of mortality for birds, and it is estimated that 100 million to one billion birds die due to window collisions annually in the US alone. However, in Brazil there have been no systematic studies on bird mortality due to collisions with man-made structures. Our aims with this study were to record the bird species that died due to collisions with windows in an Important Bird Area of southeastern Brazil, accessing the effects of species characteristics (forest dependence, wing type, threaten status, endemism, migratory habits) and climatic seasonality on bird-window collisions. Dead birds were collected daily during 2010 to 2013 and occasional records were obtained from 2000–2009 and 2014–2015 in *Reserva Particular do Patrimônio Natural Santuário do Caraça*, Minas Gerais, southeastern Brazil. We found 168 birds individuals of 57 species dead due to collisions against windows. Individuals classified as forest dependent and with elliptical type wings were the most common among birds dead due to collisions. There was no difference between the number of dead individuals in the dry and rainy seasons, and rainfall was not correlated with bird collisions. The occurrence of threatened, endemic and migrant species in our sample demonstrates the importance to continue this type of research in Brazil and other localities throughout the Neotropics. Our data can support studies that investigate the influence of other factors and characteristics of natural history of bird collisions, particularly in areas with similar man-made structures as at our study site.

KEY-WORDS: bird collisions, mortality, natural history, RPPN Santuário do Caraça, seasonality.

INTRODUCTION

Human activities can negatively alter natural regions and biological systems, as has been recently discussed in many reports and environmental impact analyses of wild communities (Loss *et al.* 2012). Such human interference can cause significant damage, especially among birds (*e.g.* Bevanger 1994, Piorkowski 2006, Johnson *et al.* 2002, Drewitt & Langston 2008), due to their diversity and their frequent cohabitation with humans in a variety of environments (Le Corre *et al.* 2009, Ryder *et al.* 2012).

Collisions with man-made structures are the second greatest source of human-caused bird mortality worldwide (Klem-Jr. 2008). Such incidents have been documented globally (Avery *et al.* 1978, Avery 1979, Klem-Jr. 1990a, Morrinson 1998, Erickson *et al.* 2001, 2005, Veltri & Klem-Jr. 2005, Hager *et al.* 2008) and represent an important source of negative anthropic influence on nature (Banks 1979, Drewitt & Langston 2006, 2008).

The vulnerability to human impacts and the potential risk of bird collision is related differently for each species and their biological characteristics (Bevanger 1994). The magnitude of the problem is so significant that major changes in the ecology and behavior of birds have been reported (Johnson *et al.* 2002), especially regarding migratory species (Rybak *et al.* 1973, Klem-Jr. 1990a, b, Erickson *et al.* 2001, 2005, Manville 2001, Diehl *et al.* 2014). Some examples include changes in flight routes and lower flight altitudes caused by an increase in obstacles such as wind farms and electric transmission towers (Winkelman 1995, Leddy *et al.* 1999, Borden *et al.* 2010).

Some studies have related the characteristics of particular bird species with human impacts. For example, forest dependent species are more susceptible to negative changes in the environment (Marini 2001, Maldonado-Coelho & Marini 2003, Roma 2006, Ramos *et al.* 2011). Maneuverability, including wing type and flight speed, of each species relates to flight behavior and thus collisions risk (APLIC 2012, Sporer *et al.* 2013). Thus, slow-flying or walking birds do not cover large areas and thus are less prone to collisions than long-distance or fastflying species (Klem-Jr. 1989, Bevanger 1994). Lastly, seasonal and weather conditions have been reported to influence variation in the annual number of bird collisions (Bevanger 1994, Drewitt & Langston 2008). For example, the collision frequency is directly related to the increase in rainfall, which generally coincides with the reproductive period in southeastern Brazil (Marini & Durães 2001), and is a function of foraging and other biological activities, as well as reduced visibility (Gabrey & Doolber 1996, Steele 2001).

Studies of bird collisions are usually conducted in urban, suburban or rural environments and rarely in protected areas or regions that have been identified as important conservation areas (Klem-Jr. 2008, Gelb & Delacretaz 2009). Important Bird Areas (IBAs) represent a global network of important sites for the conservation of birds and biodiversity. Worldwide, 12,000 IBAs have been identified, with 234 IBAs mapped in Brazil, where endemic and threatened species occur (Develey & Goerck 2009, BirdLife International 2014). Nevertheless, several problems have been reported regarding human interference in areas devoted to conservation, for example, exploration of land use in surroundings, fragmentation, wildfires and ineffective surveillance (Lima *et al.* 2005, Rylands & Brandon 2005).

Records for bird collisions with aircraft, power lines and vehicles have been increasing in Brazil, but there remains much to be understood about this phenomenon (Nascimento *et al.* 2005, Laurance *et al.* 2009, Rosa & Bager 2012). Only a few studies have focused on bird mortality due to collisions with man-made structures in Brazil (ACS 2006, Carrano 2006, Muhlenberg College 2009, Santos *et al.* 2011, Soares *et al.* 2011, Stolk *et al.* 2015), making it difficult to make comparisons and determine influential factors. This is particularly true given the great bird diversity of Brazil and the large size of the country, thereby confounding attempts to develop preventive measures or finding solutions.

In this paper, we report on bird collisions with windows in a Brazilian protected area and IBA, considering characteristics such as forest dependence, wing type, threaten status, endemism and migratory habits of each species. We also tested for a seasonal relationship between seasons (dry and rainy) and the number of dead birds.

METHODS

Study area

The *Reserva Particular do Patrimônio Natural Santuário do Caraça* (hereafter RPPNSC - 20°05'51"S; 43°29'18"W; elevation 1290 m a.s.l.), located in the municipalities of Catas Altas and Santa Bárbara, state of Minas Gerais, southeastern Brazil, is a private reserve with 11,233 ha (Santuário do Caraça 2013), in the *Quadrilátero Ferrífero* (Iron Quadrangle) region in the southern portion of the Serra do Espinhaço (Espinhaço Mountain Range; Fig. 1). The region lies within the Atlantic Forest domain, yet close to the Cerrado domain, two world hotspots of biodiversity (Myers *et al.* 2000, Vasconcelos 2000). A very heterogeneous vegetation and different phytophysiognomies are found in RPPNSC, such as high altitude rocky fields (*campos rupestres*), semideciduous and cloud forests (Mota 2006). In contrast, historically, this protected area suffers anthropic pressure in its surroundings, such as mining and farming, interrupting the landscape connectivity, with others protected and natural areas (Vasconcelos 2013).

The climate of RPPNSC is seasonal, with well-defined dry (April to September) and rainy (October to March) seasons, with mild mean annual temperatures (18–19°C) and low (0°C or less) temperatures mainly at higher elevations (Dutra *et al.* 2002). The Köppen-Geiger climatological classification defines this area as Cwb (humid temperate climate with dry winters and temperate summers, similar to tropical climate of altitude) (Alvares *et al.* 2013) and the annual average rainfall is above 1500 mm.

In the area 372 bird species had been recorded, including 13 threatened species, 75 migrants, 74 Atlantic Forest endemics, four Cerrado endemics and four species restricted to mountain-tops of southeastern Brazil (Chesser 1994, Vasconcelos 2013). Serra do Caraça has one of the richest avifaunas of eastern Brazil, it is an important area for bird conservation on both regional and global scales (Vasconcelos & Melo-Júnior 2001, Bencke *et al.* 2006, Develey & Goerck 2009). The area is located in an IBA (BR145; BirdLife International 2009, 2012, Develey & Goerck 2009), an Endemic Bird Area (EBA 073; Stattersfield *et al.* 1998) and a Biosphere Reserve (UNESCO 2005).

Data collection

The RPPNSC is locally well known for its historical man-made architecture. One of the buildings is the Caraça Museum (Fig. 1), which is 70 m nearly from the forested vegetation and has sides that comprised large, reflective tempered glass windows (Fig. 2). On those windows (408.5 m^2) occur bird collisions under investigation in the present study.

Dead birds were collected daily, but stored in freezer by monthly lots, during 2010 to 2013, with the assistance of the environmental team of RPPNSC. Additional casual non-systematic records were carried out during 2000–2009 and 2014–2015. Specimens found dead were placed in individual plastic bags with a label

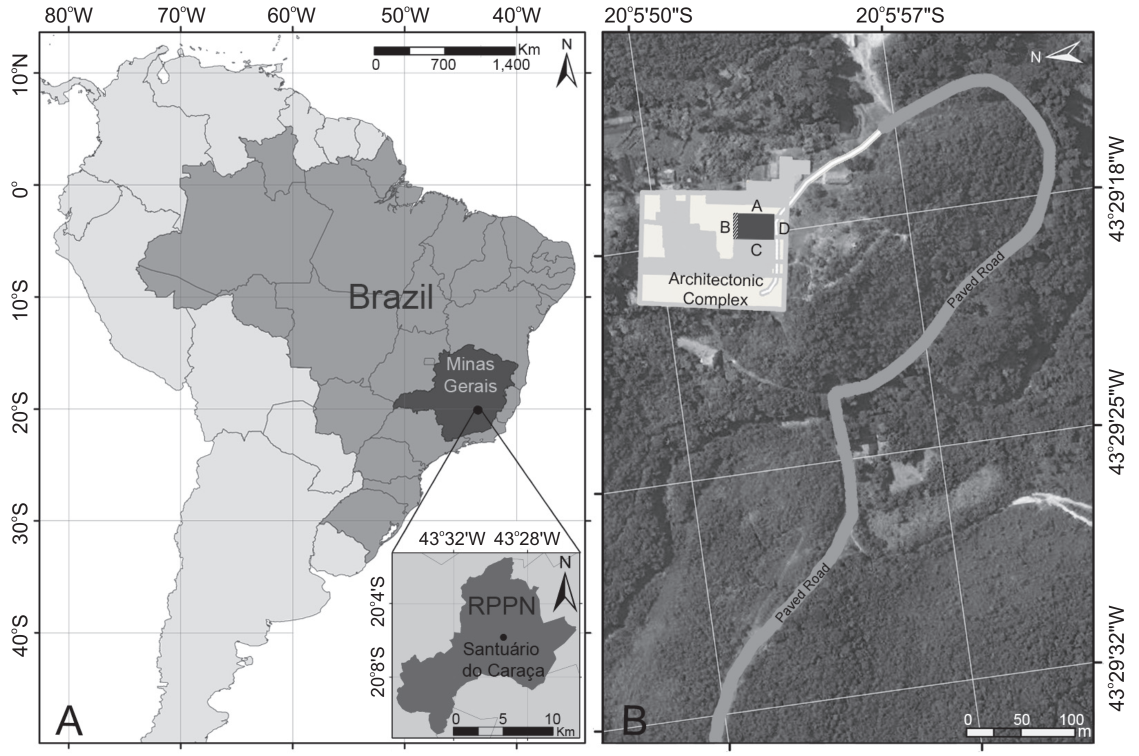

Figure 1. Location map (**A**) and aerial image of the *Reserva Particular do Patrimônio Natural Santuário do Caraça*, showing the architectural complex (**B**). The dark grey box is the Caraça Museum with sides (**A–D**) comprised of windows.

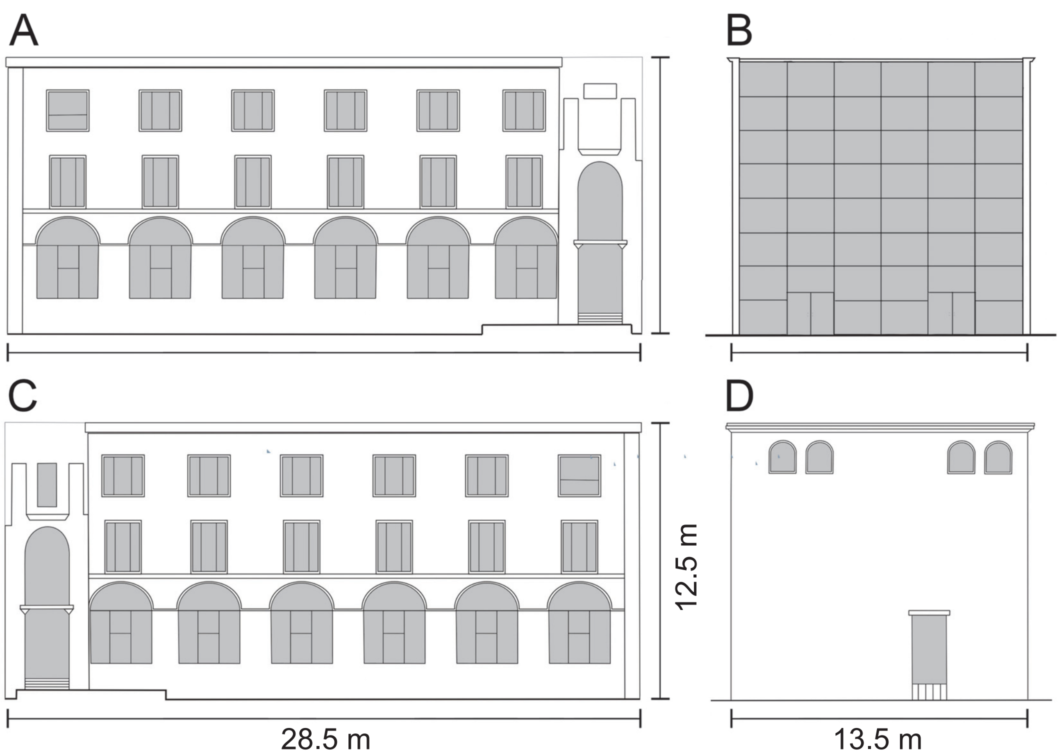

Figure 2. Architectural sketch of Caraça Museum showing the details of the building and the width, height and depth of its sides. Percentage and area (in m^2) of glass (grey areas) on each side of the Caraça Museum: (**A**) ≅ 31% (110); (**B**) ≅ 90% (151.5); (**C**) ≅ 34.9% (124.2); (**D**) ≅ 13.6% (22.8).

containing basic collection data and frozen. Specimens were deposited (mostly as study skins and/or skeletons) in the following collections: *Museu de Ciências Naturais da Pontifícia Universidade Católica de Minas Gerais* (MCNA), Department of Zoology of the *Universidade Federal de Minas Gerais* (DZUFMG) and *Museu de Zoologia da Universidade de São Paulo* (MZUSP). We identified all individuals to species level following nomenclature in Piacentini *et al.* (2015).

Data analysis

We classified the specimens qualitatively and quantitatively for attributes from the literature: I) Forest dependence (Silva 1995, Parker-III *et al.* 1996): 1) independent (species that occur in open vegetation), 2) semi-dependent (species that occur in open vegetation and forest), and 3) dependent (species found mainly in forest habitats); II) Wing types (Scott & McFarland 2010): 1) elliptical, 2) game bird, 3) high-aspect ratio, 4) high-speed, and 5) slotted high-lift; III) Threat status: 1) global (IUCN 2015), 2) national (MMA 2014a, b), and 3) state (COPAM 2010); IV) Endemism: 1) Cerrado (Silva 1995), 2) Atlantic Forest (Brooks *et al.* 1999) and 3) mountaintops of eastern Brazil (Vasconcelos 2008); and V) Migration: austral migrants (*sensu* Chesser 1994).

To test for significant differences in the proportions of collided birds among categories of forest dependence and wing types, we use separate Chi-Square tests with no difference among categories as the expected proportion. We also performed Partition Likelihood Ratio Chi-Square to evaluate relationships between categories of both of these characteristics.

To test for differences in the number of birds dead from collision between the two seasons (dry and rainy) we used the Shapiro-Wilk test for normality and, subsequently, *t*-test for two independent samples (parametric). The *F*-test was used to compare sample distributions of the two seasons. We analyzed the seasonality only for specimens for which the month of their collision was known. A rate per day (the number of collided birds by the total of days in each season) was used for comparison between the systematic sampling periods.

Using monthly rainfall (in mm) at RPPNSC during 2010–2013, we assessed differences in rainfall for each season using factorial ANOVA. To evaluate rainfall as a factor of bird mortality, we performed a Pearson product moment correlation between average monthly rainfall and number of individuals found dead from collision.

Statistical analyses were conducted in R Software (R Core Team 2017; $\alpha = 0.05$) and used all birds found dead as a result of colliding with the windows of the Caraça Museum. Plotrix package v. 3.6-1 (Lemon *et al.* 2015) was used for producing the radial graph.

RESULTS

A total of 168 specimens of 57 species (Appendix I) were found dead presumably due to collisions with glass panes of the Caraça Museum. The mortality rates for the period of systematic sampling (102 individuals in 2010–2013) were of ≅ 2.12 deaths/month and 25.50 deaths/year.

The orders most affected were Passeriformes (102 individuals) and Columbiformes (44) (Table 1). Regarding families, the most affected were Columbidae (44 individuals), Thraupidae (35), Trochilidae (16) and Hirundinidae (15), whereas the most affected genera were *Turdus* (13) and *Tangara* (11). The most commonly

Table 1. Orders of birds dead due to collisions with windows of the Caraça Museum, Minas Gerais state, Brazil, and the number of individuals for each category of forest dependence and wing type.

	Galiformes	Accipritiformes	Columbiformes	Psitaciformes	Apodiformes	Coraciiformes	Piciformes	Passeriformes	Total
Dependent	2	1	41	0	9	0	0	44	97
Semi-dependent	0	0	3	1	6	1	1	27	39
Independent	0	0	0	0	1	0	0	31	32
Elliptical	0	1	44	0	0	1	0	87	133
High-speed	0	0	0	1	16	0	0	15	32
Slotted	0	0	0	0	0	0	1	0	1
Game Bird	2	0	0	0	0	0	0	0	2
Total	2	1	44	1	16	1	1	102	168

encountered species were the Plumbeous Pigeon (*Patagioenas plumbea*) (35 individuals) and the Blue-and-white Swallow (*Pygochelidon cyanoleuca*) (13).

We found greater mortality for forest dependent (97 individuals; 57.8%) and semi-dependent (39; 23.2%) species than independent species (32; 19.0%). Forest dependence had the greatest influence on bird mortality ($\chi^2 = 46.46$; $P < 0.0001$).

Among wing types, species classified as having elliptical wings were the most affected (133 individuals; 79.2%), followed by high-speed (32; 19%), game bird (2; 1.2%) and slotted high-lift (1; 0.6%) wings. Elliptical wings differed significantly from the other categories of wing types ($\chi^2 = 277.67$; $P < 0.0001$).

The interaction between the natural history characteristics of forest dependence and wing type had a significant general value (Table 2). A significant difference was found for partition one ($\chi^2_{2\times3\ tables} = 24.11$; $P = 0.0001$), demonstrating that individuals classified as forest dependent with elliptical wings are more frequently affected by collisions.

In relation to threaten status, only two species were considered globally "Near Threatened": the Hyacinth Visorbearer *Augastes scutatus* (1 individual) and the Swallow-tailed Cotinga *Phibalura flavirostris* (2 individuals); the latter is also considered "Vulnerable" in the state of Minas Gerais. All other specimens were classified as "Least Concern" species at the global, national and/or state levels.

Endemic species were represented by 38 specimens of the Atlantic Rain Forest and one (Hyacinth Visorbearer) from the mountains of eastern Brazil. Twenty-seven individuals of 10 species of austral migrants were found dead by collisions throughout our study.

No significant seasonal mortality pattern was found between the rainy (44 individuals; rate [collided birds/rainy days] = 16.56) and dry (54; rate [collided birds/dry days] = 13.55) seasons ($t = 0.96$; $P = 0.362$; $F = 1.01$; $P = 0.99$) (Fig. 3). The significant difference in monthly rainfall between the seasons (F(seasons) = 37.44; $P < 0.0001$) was not correlated with bird mortality.

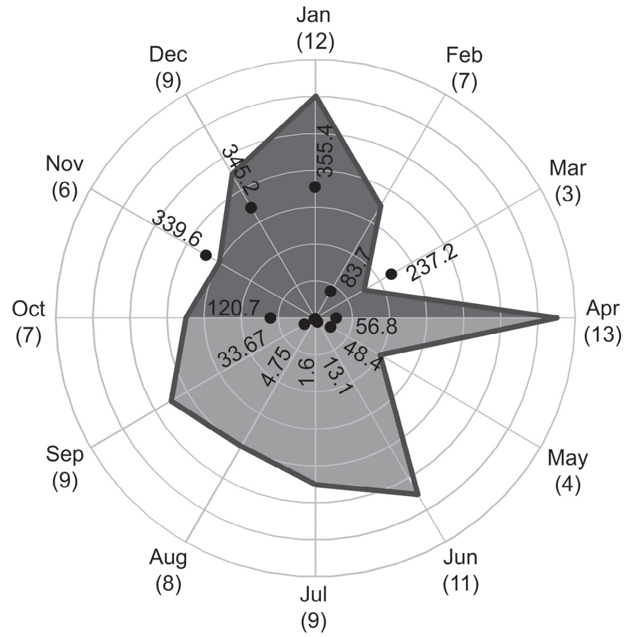

Figure 3. Radial graph of the average number of individuals found dead in each month of the two study seasons (polygon; light grey: dry season; dark grey: rainy season; grid scale: 0–14). Data points (in black) and respective numbers reveal the average monthly rainfall (mm) for 2010–2013 in *RPPN Santuário do Caraça* (grid scale: 0–700).

DISCUSSION

Sixteen percent of the total number of bird species known to occur in RPPNSC was affected by collisions with the studied structure. However, it is important to stress that, even with the helpful assistance of the environmental team of the reserve, it is possible that several dead specimens were overlooked. Specimens may have been missed due to their rapid decomposition due to natural factors such as weather, sunlight, rain, necrophagous animals (invertebrates such as ants, flies, beetles) and other biological agents (bacterial digestion) (Crawford 1971, Balcomb 1986, Pain 1991, Wobeser & Wobeser 1992). Scavengers and opportunist vertebrate predators also can remove small bird carcasses within a matter of a

Table 2. Number of individuals dead due to collisions with windows of the Caraça Museum, Minas Gerais state, Brazil, classified by category of interaction between forest dependence and wing type.

Categories	Dependent	Semi-dependent	Independent
Elliptical	86	31	16
High-speed	9	7	16
Game bird	2	0	0
Slotted high-lift	0	1	0
Chi-square value			30.295
Significance level			$P < 0.0001$

few minutes after death and it is also believed that many collisions may not result in immediate death, which may imply that most of the studies on bird mortality due to human factors are underestimates (Klem-Jr. 1990a, Morris 2002, Antworth *et al.* 2005, Kummer *et al.* 2016).

Forest dependent birds were most frequently affected by collisions in RPPNSC. We interpret this as the Caraça Museum building disrupts a natural corridor formed by the surrounding vegetation, and forest birds fail to recognize this obstacle as a change of habitat. In contrast, the lower number of forest independent species can be attributed to their ability to recognize edges in open areas, since these species should have a better perception of obstacles, and thus be more able to avoid them.

In general, forest dependent species react more negatively to environmental changes than forest independent species. For example, the presence of forests next to roads increased roadkill of forest species (Marini 2001, Ramos *et al.* 2011). Although it is known that forest birds avoid crossing large open areas (Grubb-Jr. & Doherty-Jr. 1999, Develey & Stouffer 2001), these species perform frequent movements in their environments and may cross-forest fragments, especially those species adapted to patchy environments (Marini 2001, Yabe *et al.* 2010).

The high incidence of collisions by native pigeons (Columbidae), especially the Plumbeous Pigeon, significantly influenced the interpretation of our analysis. Perhaps the abundance of this species in RPPNSC, and the patterns of its biological activities, such as feeding, dispersal and reproduction are responsible for the high collision rate of this species. In conjunction, the abundance and differential use of specific habitats by bird populations is also of fundamental importance to predicting collisions (De Lucas *et al.* 2008, Marques *et al.* 2014). Other studies also report a high incidence of accidents with Columbidae species, including birdstrikes on aircrafts and windows collisions (Dolbeer 2006, Kitowski 2011, Ocampo-Peñuela *et al.* 2016).

Different wing types are associated with different flight performances (Warham 1977, Copete 1999). In the case of power lines, flight behavior is one of the most important biological features for bird collisions (Bevanger 1994, Janss 2000). The prominent number of collisions by birds with elliptical wings in the present study indicates that birds with this characteristic have a greater tendency for collisions. Scott and McFarland (2010) explain that birds with elliptical wings have quick bursts of speed and are most adept at navigating densely vegetated habitats. This fact contextualizes the high representation of this category in our sample, especially due to the proximity of vegetation to the Caraça Museum. Further, the strong association of elliptical wings and forest dependent birds, which the most represented orders were Passeriformes and Columbiformes, can be related with the susceptible when they cross open environments and other characteristics, such as photophobia and forest proximity.

Sporer *et al.* (2013) noted that high-speed and elliptical-winged birds frequently collide with power lines. High-speed birds were represented in our sample by some species of Trochilidae and Hirundinidae, which not only possess fast flight, but also can remain in flight for a greater period of time (Scott & McFarland 2010). Jenkins *et al.* (2010) pointed out that high speed affects the reaction time of birds to avoid collisions with anthropic structures. Game birds, which generally have slotted and high-aspect wing types, were not abundant in our sample, and exhibit other flight performances such as soaring, lift and difficult take-offs.

The frequency of collisions with the large windows of the Caraça Museum can be evaluated in the context of the surrounding landscape and thus the reflections of the vegetation in the windows (Ogden 1996, Gelb & Delacretaz 2009, Klem-Jr. 2009). The Caraça Museum is adjacent to a large forested area, but is situated in an open space inside the architectural complex. Sensory analyses have determined that birds perceive such reflections as an extension of the physical environment, and their visual system is not exclusively dedicated to perceiving fixed obstacles, such as human structures, thus eventually leading to collisions with windows (Martin & Shaw 2010, Martin 2011).

Our data did not show any seasonal difference in bird mortality between dry and rainy seasons. The RPPNSC experiences high variation in monthly rainfall, but slight oscillations in other abiotic factors such as temperature and wind speed and direction, as has been reported previously (Moreira & Pereira 2013). A relationship between bird collisions with artificial structures and seasonal patterns can be more important in regions where climate conditions exhibit larger variations, but is also related to routes and additional types of migrant species (*e.g.* Klem-Jr. 1989, Borden *et al*. 2010).

Other weather and meteorological factors, such as daily temperature, air humidity, sunlight, clouds and mist, change the perception of, and interaction with, the physical environmental by birds (*e.g.* Bevanger 1994, Drewitt & Langston 2008, Martin 2011). In the Neotropical region, the influence of these conditions on bird collisions is still unknown, and there certainly are other environmental factors shaping this interaction, such as changes in the composition of food resources or patterns of other biological activities. Further exploration of seasonal patterns of birds may help to uncover fundamental answers about bird collisions, and provide important information for strategies to mitigate this problem (Borden *et al*. 2010).

It is important to stress that all bird species are not equally susceptible to mortality by collisions (Bevanger 1994, Drewitt & Langston 2008, Loss *et al.* 2014). Borden *et al.* (2010) mention that bird collisions are a complex question and there are no simple relationships that explain it in its entirety. Furthermore, species behavioral and ecological characteristics can be modified over time to adapt to man-made changes in nature.

Our data can be useful for preventing future negative impacts on the avifauna of several forested areas with man-made constructions similar to the Caraça Museum, a common type of building (large windows near forest areas) present in many natural places in Brazil, such as the Serra da Mantiqueira, for example (Vasconcelos & D'Angelo-Neto 2009). Some mitigating and preventive measures are indicated as practical ways to reduce bird mortality in several places, such as cover buildings with opaque curtains or safety nets and add colorful decals or predators silhouettes on windows (Klem-Jr. 1990b, 2009, Bevanger 1994).

Furthermore, there is a range of additional natural history and ecological characteristics to explore that may provide insight into collisions, such as wing biometry, speed/distance in flight and comparative optical systems. This information could be integrated with species survey, population dynamics and abundance data in analyses to better understand the causes of bird collisions.

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APPENDIX I

List of species found dead due to collisions with the Caraça Museum (*RPPN Santuário do Caraça*) and their respective data, as follow: Forest dependence: D - Dependent; S - Semi-dependent and; I - Independent; Wing type: E - Elliptical; HS - High-Speed; ST - Slotted; GB - Game Bird; Conservation Status: LC - Least Concern; NT - Near Threatened; [G] Globally Level; [N] National Level; [S] State Level; Seasonality: month of collision (number of individuals that collided); [AF] Atlantic Rain Forest Endemism; [MT] Mountaintops of Southeastern Brazil Endemism; [M] Migratory species.

Taxon	Number of individual	Forest dependence	Wing type	Conservation status	Seasonality
Cracidae Rafinesque, 1815					
Dusky-legged Guan *Penelope obscura* Temminck, 1815	2	D	GB	LC[G, N, S]	2 (1), 4 (1)
Accipitridae Vigors, 1824					
Bicolored Hawk [M] *Accipiter bicolor* (Vieillot, 1817)	1	D	E	LC[G, N, S]	-
Columbidae Leach, 1820					
Blue Ground-Dove *Claravis pretiosa* (Ferrari-Perez, 1886)	1	S	E	LC[G, N, S]	11 (1)
Plumbeous Pigeon *Patagioenas plumbea* (Vieillot, 1818)	35	D	E	LC[G, N, S]	1 (4), 2 (2), 4 (2), 5 (1), 6 (1), 9 (1), 12 (2)
White-tipped Dove *Leptotila verreauxi* Bonaparte, 1855	2	S	E	LC[G, N, S]	1 (1)
Gray-fronted Dove *Leptotila rufaxilla* (Richard & Bernard, 1792)	4	D	E	LC[G, N, S]	4 (2)
Ruddy Quail-Dove *Geotrygon montana* (Linnaeus, 1758)	2	D	E	LC[G, N, S]	6 (1), 9 (1)
Psittacidae Rafinesque, 1815					
White-eyed Parakeet *Psittacara leucophthalmus* (Statius Muller, 1776)	1	S	HS	LC[G, N, S]	-
Trochilidae Vigors, 1825					
Planalto Hermit *Phaethornis pretrei* (Lesson & Delattre, 1839)	1	S	HS	LC [G, N, S]	-
Scale-throated Hermit [AF] *Phaethornis eurynome* (Lesson, 1832)	1	D	HS	LC [G, N, S]	7 (1)
White-vented Violetear *Colibri serrirostris* (Vieillot, 1816)	1	S	HS	LC [G, N, S]	4 (1)
Glittering-bellied Emerald [M] *Chlorostilbon lucidus* (Shaw, 1812)	3	S	HS	LC [G, N, S]	3 (1)
Violet-capped Woodnymph [AF] *Thalurania glaucopis* (Gmelin, 1788)	1	D	HS	LC [G, N, S]	7 (1)
Versicolored Emerald *Amazilia versicolor* (Vieillot, 1818)	1	D	HS	LC [G, N, S]	10 (1)
Sapphire-spangled Emerald *Amazilia lactea* (Lesson, 1832)	3	D	HS	LC [G, N, S]	4 (1), 6 (1), 7 (1)
Brazilian Ruby [AF] *Heliodoxa rubricauda* (Boddaert, 1783)	3	D	HS	LC [G, N, S]	10 (1)
Hyacinth Visorbearer [MT] *Augastes scutatus* (Temminck, 1824)	1	I	HS	NT [G]; LC [N, S]	4 (1)
Amethyst Woodstar [M] *Calliphlox amethystina* (Boddaert, 1783)	1	S	HS	LC [G, N, S]	-

Taxon	Number of individual	Forest dependence	Wing type	Conservation status	Seasonality
Alcedinidae Rafinesque, 1815					
Green Kingfisher *Chloroceryle americana* (Gmelin, 1788)	1	S	E	LC [G, N, S]	1 (1)
Ramphastidae Vigors, 1825					
Toco Toucan *Ramphastos toco* Statius Muller, 1776	1	S	ST	LC [G, N, S]	-
Thamnophilidae Swainson, 1824					
Large-tailed Antshrike [AF] *Mackenziaena leachii* (Such, 1825)	1	D	E	LC [G, N, S]	7 (1)
Furnariidae Gray, 1840					
Rufous Hornero *Furnarius rufus* (Gmelin, 1788)	1	I	E	LC [G, N, S]	-
Pallid Spinetail [AF] *Cranioleuca pallida* (Wied, 1831)	2	D	E	LC [G, N, S]	2 (1), 8 (1)
Pipridae Rafinesque, 1815					
Serra do Mar Tyrant-Manakin [AF] *Neopelma chrysolophum* Pinto, 1944	1	D	E	LC[G, N, S]	9 (1)
White-bearded Manakin *Manacus manacus* (Linnaeus, 1766)	1	D	E	LC[G, N, S]	5 (1)
Pin-tailed Manakin [AF] *Ilicura militaris* (Shaw & Nodder, 1809)	2	D	E	LC[G, N, S]	9 (1)
Swallow-tailed Manakin [AF] *Chiroxiphia caudata* (Shaw & Nodder, 1793)	4	D	E	LC[G, N, S]	4 (1), 5 (1), 6 (1)
Tityridae Gray, 1840					
White-winged Becard [M] *Pachyramphus polychopterus* (Vieillot, 1818)	1	S	E	LC[G, N, S]	9 (1)
Cotingidae Bonaparte, 1849					
Swallow-tailed Cotinga [M] *Phibalura flavirostris* Vieillot, 1816	2	D	E	NT[G]; LC[N]; VU[S]	11 (1)
Rhynchocyclidae Berlepsch, 1907					
Gray-hooded Flycatcher [AF] *Mionectes rufiventris* Cabanis, 1846	5	D	E	LC[G, N, S]	6 (2), 11 (1)
Hangnest Tody-Tyrant [AF] *Hemitriccus nidipendulus* (Wied, 1831)	2	S	E	LC[G, N, S]	6 (2)
Tyrannidae Vigors, 1825					
Great Kiskadee [M] *Pitangus sulphuratus* (Linnaeus, 1766)	2	I	E	LC[G, N, S]	-
Velvety Black-Tyrant [AF] *Knipolegus nigerrimus* (Vieillot, 1818)	6	S	E	LC[G, N, S]	5 (1), 6 (2)
Hirundinidae Rafinesque, 1815					
Blue-and-white Swallow [M] *Pygochelidon cyanoleuca* (Vieillot, 1817)	13	I	HS	LC[G, N, S]	1 (3), 10 (1), 12 (4)
Southern Rough-winged Swallow [M] *Stelgidopteryx ruficollis* (Vieillot, 1817)	2	I	HS	LC[G, N, S]	-
Turdidae Rafinesque, 1815					
Yellow-legged Thrush [M] *Turdus flavipes* Vieillot, 1818	3	D	E	LC[G, N, S]	4 (1)
Pale-breasted Thrush *Turdus leucomelas* Vieillot, 1818	1	S	E	LC[G, N, S]	-
Rufous-bellied Thrush *Turdus rufiventris* Vieillot, 1818	2	I	E	LC[G, N, S]	12 (1)

Taxon	Number of individual	Forest dependence	Wing type	Conservation status	Seasonality
Creamy-bellied Thrush [M] *Turdus amaurochalinus* Cabanis, 1850	2	S	E	LC[G, N, S]	10 (2)
White-necked Thrush *Turdus albicollis* Vieillot, 1818	5	D	E	LC[G, N, S]	7 (1), 8 (1), 12 (1)
Passerellidae Cabanis & Heine, 1850					
Rufous-collared Sparrow *Zonotrichia capensis* (Statius Muller, 1776)	1	I	E	LC[G, N, S]	1 (1)
Icteridae Vigors, 1825					
Red-rumped Cacique *Cacicus haemorrhous* (Linnaeus, 1766)	2	S	E	LC[G, N, S]	2 (1), 11 (1)
Shiny Cowbird *Molothrus bonariensis* (Gmelin, 1789)	1	I	E	LC[G, N, S]	-
Thraupidae Cabanis, 1847					
Cinnamon Tanager *Schistochlamys ruficapillus* (Vieillot, 1817)	1	I	E	LC[G, N, S]	11 (1)
Sayaca Tanager *Tangara sayaca* (Linnaeus, 1766)	6	S	E	LC[G, N, S]	2 (1), 8 (1), 9 (1), 10 (1)
Palm Tanager *Tangara palmarum* (Wied, 1821)	1	S	E	LC[G, N, S]	8 (1)
Golden-chevroned Tanager [AF] *Tangara ornata* (Sparrman, 1789)	2	D	E	LC[G, N, S]	2 (1)
Burnished-buff Tanager *Tangara cayana* (Linnaeus, 1766)	2	I	E	LC[G, N, S]	-
Saffron Finch *Sicalis flaveola* (Linnaeus, 1766)	3	I	E	LC[G, N, S]	-
Uniform Finch [AF] *Haplospiza unicolor* Cabanis, 1851	4	D	E	LC[G, N, S]	4 (1), 7 (1), 12 (1)
Black-goggled Tanager [AF] *Trichothraupis melanops* (Vieillot, 1818)	1	D	E	LC[G, N, S]	8 (1)
Ruby-crowned Tanager [AF] *Tachyphonus coronatus* (Vieillot, 1822)	4	D	E	LC[G, N, S]	4 (1), 8 (1), 9 (1)
Swallow Tanager *Tersina viridis* (Illiger, 1811)	1	D	E	LC[G, N, S]	4 (1)
Blue Dacnis *Dacnis cayana* (Linnaeus, 1766)	5	S	E	LC[G, N, S]	7 (1)
Sporophila sp.	2	I	E	-	1 (1)
Yellow-bellied Seedeater *Sporophila nigricollis* (Vieillot, 1823)	1	I	E	LC[G, N, S]	7 (1)
Green-winged Saltator *Saltator similis* d'Orbigny & Lafresnaye, 1837	1	S	E	LC[G, N, S]	-
Fringillidae Leach, 1820					
Blue-naped Chlorophonia *Chlorophonia cyanea* (Thunberg, 1822)	6	D	E	LC[G, N, S]	3 (1), 6 (1), 7 (1)