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PATTERNS OF BIRD MORTALITY BY MAN-MADE STRUCTURES IN AN IMPORTANT BIRD AREA OF SOUTHEASTERN BRAZIL

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"Padrões de mortalidade de aves devido a fatores humanos em uma área de importância para a conservação de aves do sudeste do Brasil"

Lucas Penna Soares Santos

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RESUMO

As mortalidades de aves causadas por alterações humanas são fatores de perda de biodiversidade em escala mundial. Colisões de aves contra vidraças são consideradas a segunda maior fonte humana de mortalidade e estima-se que 100 milhões a um bilhão de indivíduos sofram com este impacto apenas nos Estados Unidos, anualmente. No entanto, no Brasil existem poucos estudos produzidos a partir de dados sistemáticos sobre este tema. Nossos objetivos foram registrar indivíduos que sofreram colisões em vidraças em uma área protegida e *Important Bird Area* do sudeste do Brasil e avaliar a representatividade das características de dependência florestal e os tipos de asas nestes espécimes. Além disso, verificamos a presença de espécies ameaçadas, endêmicas e migratórias e se existe alguma influência sazonal nas colisões de aves no local. Foi realizada a coleta sistemática de aves encontradas mortas durante 2010-2013 e registros ocasionais entre 2000-2009 e 2014-2015 na RPPN Santuário do Caraça, Minas Gerais. Foram encontradas 168 aves mortas pelas colisões nas vidraças, representantes de 57 espécies. Indivíduos classificados como dependentes de florestas e com os tipos de asa na forma elípticas foram mais afetados por colisões. Não houve diferenças significativas entre o número de indivíduos colididos nas estações seca e chuvosa e o índice pluviométrico não foi um fator correlacionado com as colisões de aves. A ocorrência de espécies ameaçadas, endêmicas e migrantes no nosso estudo demonstra a relevância de prosseguir com esta linha de pesquisa no Brasil e em outras localidades da Região Neotropical. Nossos dados podem ser úteis para embasar estudos que abordem outros fatores de influência e características de história natural nas colisões das aves, principalmente em áreas com estruturas semelhantes à RPPN Santuário do Caraça.

Palavras-chave: colisões de aves, RPPN Santuário do Caraça, história natural, sazonalidade.

ABSTRACT

The bird mortalities caused by human changes are worldwide factors of biodiversity loss. Collisions of birds against window are considered the second largest human source of mortality and it is estimated that 100 million to a billion birds suffer with the impact only in the United States annually. However, in Brazil there are few studies produced from systematic data on this topic. Our aims were to register individuals who suffered collisions in windows in a protected area and Important Bird Area of southeastern Brazil and assess the representativeness of forest dependence and wings types characteristics in these specimens. In addition, we check the presence of threatened, endemic and migratory species, and if there is seasonal influence on bird collisions on locality. The systematic collection of birds found dead were made during 2010-2013 and occasional records between 2000-2009 and 2014-2015 in the RPPN Santuário do Caraça, Minas Gerais. We found 168 birds dead by collisions in the windows, representing 57 species. Individuals classified as forest dependent and elliptical wing types were more affected by collisions. There was no difference between the number of individuals collided in the dry and rainy seasons and rainfall was not a factor correlated with collisions of birds. The occurrence of threatened, endemic and migrant species in our sample demonstrates the importance of continuing with this line of research in Brazil and others localities in Neotropical regions. Our data may be useful to support works which approach others influence factors and characteristics of natural history on the bird collisions, mainly in other areas with similar structures to RPPN Santuário do Caraça.

Keywords: bird collisions, RPPN Santuário do Caraça, natural history, seasonality.

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APRESENTAÇÃO

Todos os grupos taxonômicos de aves sofrem negativamente com os impactos causados pelo homem na natureza e estão sujeitos à mortalidade por fatores antrópicos (ERICKSON *et al.*, 2005). Distribuindo-se em diversas regiões do mundo, as ocorrências de impactos antrópicos negativos aumentam a perturbação global sobre as comunidades de aves silvestres (*e.g.*, AVERY, 1979; DREWITT; LANGSTON, 2006; BAYNE *et al.*, 2012).

Alguns fatores que causam mortalidade em aves são: eletrocuções em linhas de transmissão de energia, predação por gatos domésticos, colisões por automóveis, aviões e turbinas eólicas, contaminação por pesticidas e outras causas, como derramamento de óleo e pesca acidental por espinhéis (ERICKSON *et al.*, 2005). A destruição de habitats naturais é o impacto com maior relevância negativa para aves silvestres, sendo que as alterações nestes ambientes desequilibram os recursos fundamentais dos quais as espécies dependem para sobreviver (KLEM, 2008). Constata-se que a segunda fonte humana de mortalidade é representada por colisões em construções civis (BANKS, 1979; KLEM, 2008).

As estimativas de mortalidade de aves causada por colisões em estruturas artificiais variam anualmente de 100 milhões a um bilhão de indivíduos apenas nos Estados Unidos e de 16 a 42 milhões no Canadá (KLEM, 1990a; MACHTANS *et al.*, 2013). Tal fator representa uma forte influência antrópica negativa, havendo relatos em todos os continentes (KLEM, 1990b; MORRINSON, 1998; ERICKSON *et al.*, 2001; 2005; VELTRI; KLEM, 2005; HAGER *et al.*, 2008).

No entanto, no Brasil existem poucos trabalhos focados nas mortalidades de aves por colisões, produzidos a partir de dados sistemáticos e em uma mesma localidade. Um estudo realizado em Paranaguá (PR) registrou 106 aves encontradas mortas, durante três anos e nove meses (CARRANO, 2006). Uma Instituição Educacional dos Estados Unidos apresenta um sumário *online* com 41 espécies mortas por colisões no Brasil (MUHLENBERG COLLEGE, 2009). Outras colisões em 133 exemplares foram levantadas em uma edificação no município de Brasília, durante 12 meses de estudo (ACS, 2006). Santos *et al.* (2011) e Soares *et al.* (2011) registraram colisões em poucas espécies em edifícios nos municípios de São José dos Campos (SP) e Viçosa (MG), respectivamente. Recentemente, a ocorrência de 110 aves colididas (12 spp.) foi verificada durante um ano, em um município litorâneo de Santa Catarina (STOLK *et al.*, 2015).

Existem, portanto, poucos registros para o país e são necessários mais estudos para compreender melhor quais fatores são mais influentes e quais espécies ou locais apresentam maior taxa de colisão. Nesse contexto, apresentamos mais um registro para esta linha de pesquisa no Brasil, realizando um estudo sobre a mortalidade de aves causada por fatores antrópicos em uma área protegida do sudeste brasileiro, a Reserva Particular do Patrimônio Natural (RPPN) do Santuário do Caraça.

A Serra do Caraça (centrada em 20º05’51”S 43º29’18”W; altitude 1.290 m) está localizada entre os municípios de Catas Altas e Santa Bárbara, na região centro-sudeste de Minas Gerais, reconhecida como Unidade de Conservação pela Portaria nº 32/94 - IBAMA e com uma área equivalente a 11.233 ha. A reserva está inserida no Quadrilátero Ferrífero, na porção sul da Cadeia do Espinhaço e no bioma de Mata Atlântica, próxima aos limites do Cerrado (SANTUÁRIO DO CARAÇA, 2013). A composição das fitofisionomias do Caraça é feita por formações florestais, como matas de galeria, ciliares, nebulares (acima de 1.900 m de altitude) e de encosta, e formações campestres, a exemplo de campo sujo, limpo e rupestre (SALINO; MOTA, 2013).

A RPPN possui uma estrada de acesso (13 km) para o conjunto arquitetônico-histórico, que é composto por edificações (Figura 1). Destas, uma é representada pelo Museu de História do Caraça, inaugurado em 1990 e constituído por longas vidraças refletoras, onde ocorreu a maior parte das colisões de aves (Figura 2). Eventualmente, também foram registradas casos de atropelamentos em aves na estrada de acesso.

Figura 1 - Conjunto arquitetônico histórico da Reserva Particular de Patrimônio Natural Santuário do Caraça

Foto: Lucas Penna Soares Santos.

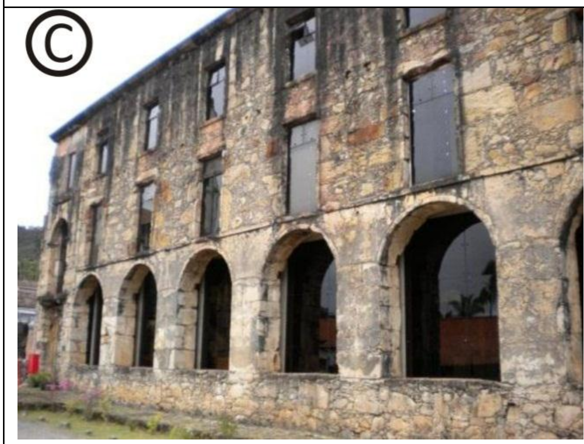
A área é considerada uma *Important Bird Area* (código BR145) e uma *Endemic Bird Area* (STATTERSFIELD et al., 1998; DEVELEY; GOERCK, 2009; BIRDLIFE INTERNATIONAL, 2014), abrigando 372 espécies de aves, incluindo espécies migratórias e endêmicas da Mata Atlântica, Cerrado e de topos de montanha do sudeste brasileiro (VASCONCELOS, 2013).

Áreas Importantes para a Conservação das Aves no Brasil (IBAs) representam uma rede global de locais de grande importância para a conservação de aves e da biodiversidade. No mundo inteiro, 12.000 locais já foram identificados como IBAs e mais de 200 países participam do programa, sendo este beneficiado pelo esforço de conservação (BIRDLIFE INTERNATIONAL, 2014). No Brasil, foram identificadas 234 IBAs que totalizam 93,7 milhões de hectares (cobertura de 11% do país), envolvendo áreas de endemismo de importância extrema para a conservação em todos os biomas (DEVELEY; GOERCK, 2009).

Figura 2 - Lados da edificação do Museu de História do Caraça

Lado A: Entrada do Museu.

Lado B: Área voltada para o Parquinho.



Lado C: Área voltada para a Hospedaria.

Lado D: Área voltada para o Calvário.

Fotos: Marcelo Ferreira de Vasconcelos.

Alterações comportamentais e ecológicas foram verificadas em grupos de aves que sofrem com colisões (JOHNSON et al., 2002). Por exemplo, mudanças nas rotas e na altura de voo, principalmente em espécies com rotas migratórias que atravessam áreas urbanas e onde há torres elétricas ou eólicas (WINKELMAN, 1995; LEDDY *et al.*, 1999; CALVIN *et al.*, 2010). De uma forma geral, as análises das colisões de aves por fatores antrópicos apresentam lacunas e são necessárias mais informações sobre os fatores de interação entre as espécies e as edificações, para explicar estes fenômenos (KLEM, 1989).

Neste trabalho, nossos objetivos foram registrar indivíduos que sofreram colisões em vidraças na RPPN Santuário do Caraça e avaliar a representatividade das características de dependência florestal e os tipos de asas nestes espécimes. Além disso, verificamos se existe alguma influência sazonal nas colisões de aves no local. Apresentamos o estudo a seguir, intitulado “Patterns of bird mortality by man-made structures in an Important Bird Area of southeastern Brazil”, sob as normas da revista *Bird Conservation International*, para a qual pretende-se submetê-lo para publicação.

REFERÊNCIAS

AVERY, M. L. **Review of avian mortality due to collisions with manmade structures**. Lincoln, University of Nebraska: Wildlife Damage Management Internet Center for Bird Control Seminars Proceedings, 11 p., 1979.

BANKS, R. C. **Human related mortality of birds in the united states**. Washington, United States Department of the interior fish and wildlife service: Special Scientific Report-Wildlife, n. 215, 17p., 1979.

BAYNE, E. M.; SCOBIE, C. A.; RAWSON-CLARCK, M. Factors influencing the annual risk of bird-window collisions at residential structures in Alberta, Canada. **Wildlife Research**, v. 39, n. 7, p. 583-592, 2012.

BIRDLIFE INTERNATIONAL. **Important Bird and Biodiversity Areas**: A global network for conserving nature and benefiting people. Cambridge, UK: BirdLife International. 2014.

CALVIN, B. W.; LOCKART, O. M.; JONES, A. W.; LYONS, M. S. Seasonal, Taxonomic, and Local Habitat Components of Bird-window Collisions on an Urban University Campus in Cleveland, OH. **The Ohio Journal of Science**, v. 110, n. 3, p. 44-52, 2010.

CARRANO, E. **Composição e conservação da avifauna na Floresta Estadual do Palmito, município de Paranaguá, Paraná**. Dissertação de Mestrado, Universidade Federal do Paraná, Pós-graduação em Engenharia Florestal, 125p., 2006

DEVELEY, P. F.; GOERCK, J. M. **Important Bird Areas Americas**: Brazil. In: DEVENISH. C.; FERNÁNDEZ, D. F. D.; CLAY, R. P.; DAVISON, I.; ZABALA, I. Y. Important Bird Areas Americas - Priority sites for biodiversity conservation. Quito, Ecuador: BirdLife International (BirdLife Conservation Series), n. 16, p. 99-112, 2009.

DREWITT, A.; LANGSTON, R. H. W. Assessing the impacts of wind farms on birds. **IBIS**, v. 148, p. 29-42, 2006.

ERICKSON, W. P.; JOHNSON, G. D.; YOUNG JR., D. P. A summary and comparison of bird mortality from anthropogenic causes with an emphasis on collisions. **USDA Forest Service General Technical Report**, v. 191, p. 1029-1042, 2005.

ERICKSON, W. P.; JOHNSON, G. D.; STRICKLAND, M. D.; YOUNG JR., D.; SERNKA, K, J.; GOOD, R. E. **Avian Collisions with Wind Turbines**: A Summary of Existing Studies and Comparisons to Other Sources of Avian Collision Mortality in the United States. National Wind Coordinating Committee (NWCC) Resource Document, 62 p., 2001.

HAGER, S. B.; TRUDELL, H.; MCKAY, K. J.; CRANDALL, S. M.; MAYER, L. Bird density and mortality at windows. **The Wilson Journal of Ornithology**, v. 120, n. 3, p. 550-564, 2008.

JOHNSON, G. D.; ERICKSON, W. P.; STRICKLAND, M. D.; SHEPHERD, M. F.; SHEPHERD, D. A.; SARAPPO, A. S. Collision Mortality of Local and Migrant Birds at a Large-Scale Wind-Power Development on Buffalo Ridge, Minnesota. **Wildlife Society Bulletin**, v. l, n. 3, p. 879-887, 2002

KLEM, D. JR. Bird: Window Collisions. **The Wilson Bulletin**, v. 101, n. 4, p. 606-620, 1989.

KLEM, D. JR. Collisions between birds and windows: Mortality and prevention. **Journal of Field Ornithology**, v. 61, p. 120-128, 1990a.

KLEM, D. JR. Bird Injuries, Cause of Death, and Recuperation from Collisions with Windows (Heridas,Causas de Muerte y Restablecimiento de Aves que Chocan con Ventanas). **Journal of Field Ornithology**, v. 61, n. 1, p. 115-119, 1990b.

KLEM, D. JR. Avian mortality at windows: the second largest human source of bird mortality on earth. **Proceedings of the Fourth International Partners in Flight Conference: Tundra to Tropics**, p. 244-251, 2008.

LEDDY, K, L.; HIGGINS, K. F.; NAUGLE, D. E. Effects of Wind Turbines on Upland Nesting Birds in Conservation Reserve Program Grasslands. **The Wilson Bulletin**, v. 111, n.1, p. 100-104, 1999.

MACHTANS, C. S.; WEDELES, C. H. R.; BAYNE, E. M. A first estimate for Canada of the number of birds killed by colliding with buildings. **Avian Conservation and Ecology**, v. 8, n. 2, p. 6, 2013.

ACS - Assessoria de Comunicação Social da Universidade de Brasília. Prédio espelhado atrai pássaros para a morte. Jornal de Brasília, 2006. Disponível em: http://www.secom.unb.br/unbcliping2/2006/cp060306-12.htm.

MORRINSON, M. Avian Risk and Fatality Protocol. NREL/SR-500-24997, 1998, 10p.
MORRISON, M. L. **Avian risk and fatality protocol.** USA, Golden, National Renewable Energy Laboratory, 10 p., 1998.

MUHLENBERG COLLEGE. **Brazil - 41 Species documented to have collided with sheet glass or plastic**. Acopian Center for Ornithology. Disponível em: <http://www.muhlenberg.edu/main/academics/biology/acopiancenterforornithology/brazil/>. 2009.

SALINO, A.; MOTA, R. C. **Vegetação**. In: SANTUÁRIO DO CARAÇA. Plano de manejo da RPPN “Santuário do Caraça”. Província Brasileira da Congregação da Missão. Catas Altas/Santa Bárbara, Minas Gerais, 195p., 2013.

SANTOS, T. M.; CUNHA, J. G.; MONTEIRO, A. R. **Utilização de silhuetas para minimizar e/ou evitar, colisão de aves sobre as vidraças na passarela do Instituto de Pesquisa e Desenvolvimento - IP&D em São José dos Campos, SP/Brasil**. In: X Encontro Latino Americano de Pós-Graduação, São José dos Campos, Brasil, 2011.

SANTUÁRIO DO CARAÇA. **Plano de manejo da RPPN "Santuário do Caraça"**. Província Brasileira da Congregação da Missão. Catas Altas/Santa Bárbara, Minas Gerais, 195p., 2013.

SOARES, P. K. R.; PORTUGAL, G. C.; COSTA, M. C.; UZAI, L. M. S.; GONÇALVES, N. C. TEIXEIRA, J. P. G.; DINIZ, G. P.; SOUZA, A. Z.; RIBON, R. **Bird collisions against buildings at the Universidade Federal de Viçosa, Viçosa, Minas Gerais, Brazil**. In: IX Congresso De Ornitología Neotropical, Cusco, Peru, 2011.

STATTERSFIELD, A. J.; CROSBY, M. J.; LONG, A. J.; WEGE, D. C. **Endemic Bird Areas of the world**: Priorities for Biodiversity Conservation. UK, Smithsonian: BirdLife International (BirdLife Conservation Series), n. 7, 864 p., 1998.

STOLK, A. S.; GIRELLI, C.; MIGUEL, L. P.; BENEDET, G.; CASCAES, M. Avifauna collision on glass fronts of a urban area in Balneário Rincão, Santa Catarina. **Revista Tecnologia e Ambiente**, v. 21, n. 1, p. 249-263, 2015.

VASCONCELOS, M. F. **Avifauna**. In: SANTUÁRIO DO CARAÇA. Plano de manejo da RPPN "Santuário do Caraça". Província Brasileira da Congregação da Missão. Catas Altas/Santa Bárbara, Minas Gerais, 195p., 2013.

VELTRI, C. J.; KLEM, D. JR. Comparison of fatal bird injuries from collisions with towers and windows. **Journal of Field Ornithology**, v. 76, n. 2, p. 127-133, 2005.

WINKELMAN, J. E. Bird/wind turbine investigations in Europe. In: DENVER, C. O. **Proceedings of the National Avian-Wind Power Planning Meeting**. Ontario, King City: Environmental Research Associates., p. 43-47., 1995.

CAPÍTULO 1

Bird mortality by man-made structures in an Important Bird Area of southeastern Brazil

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Bird mortality by man-made structures in an Important Bird Area of southeastern Brazil

Running Title: Bird mortality in an Important Bird Area in Brazil

LUCAS PENNA, VINÍCIUS F. ABREU and MARCELO F. VASCONCELOS

Introduction

Human activities can alter negatively natural regions and biological systems, being a question recently discussed by many reports and environmental impacts analyses in wild communities (Loss *et al.* 2012). In this context, innumerous damages are caused by human interference, especially among birds (e.g., Bevanger 1994, Piorkowski 2006, Johnson *et al.* 2002, Drewitt and Langston 2008). This occurs due the wide range of different species of birds and their frequently cohabitations with humans in several environments (Corre *et al.* 2009, Ryder *et al.* 2012).

Klem (2008) noted that the second source of bird mortality worldwide by humans is represented by collisions against man-made structures. Reports in this field are globally documented (Avery 1978, 1979, Klem 1990a, Morrinson 1998, Erickson *et al.* 2001, 2005, Veltri and Klem 2005, Hager *et al.* 2008) and represent an important source over the anthropic influence in nature (Banks 1979, Drewitt and Langston 2006, 2008).

Records for bird collisions with aircraft, power lines and roadkills are increasing in Brazil, but there are still knowledge gaps (Nascimento 2005, Laurance *et al.* 2009, Rosa and Bager 2012). Specifically, only few studies are focused on bird mortality by collisions in man-made structures (ACS 2006, Carrano 2006, Muhlenberg College 2009, Santos *et al.* 2011, Soares *et al.* 2011, Stolk *et al.* 2015). This makes the comparison of the influence factors in the phenomena of collisions is weak in this area, considering the great biodiversity and size of the country to the Neotropical region and creating gaps in the search for possible preventive measures or solutions.

The different biological features of bird species are related to their potential risk of collisions and others humans impacts (Bevanger 1994). Such events present a relevant magnitude that major changes in ecological and behavioral features in birds have been reported (Johnson *et al.* 2002), especially concerning migrant species (Rybak *et al.* 1973, Klem 1990a, b, Erickson *et al.* 2001, 2005, Manville 2001, Diehl *et al.* 2014).

Some examples include changes in flights routes and lower flight altitude caused by the increase of obstacles such as wind farms and electric towers (Winkelman 1995, Leddy *et al.* 1999, Calvin *et al.* 2010).

In this context, some works associates birds' characteristics with human impacts. For example, dependent forest species are more susceptible to negatives changes in the environmental (Marini 2001, Maldonado-Coelho and Marini 2003, Roma 2006, Ramos et al. 2011). In other point, the maneuverability, wing types and speed of each specie approaching to an obstacle is related with the flight behaviour and the collisions risk (APLIC 2012, Sporer et al. 2013). Thus, slow-flying or walkers birds do not perform large displacement and are less affected by collisions than long-distance or fast-flying specimens (Klem 1989, Bevanger 1994). For last, seasonal and weather conditions influence the variation of annual index of bird collisions (Bevanger 1994, Drewitt and Langston 2008). For example, the increase of rains is related directly with the collisions in function of foraging and biological activities, as well as reducing bird capacity and visibility on environment to avoid collisions (Gabrey and Doolber 1996, Steele 2001).

Bird collisions studies are most conducted in urban, suburban or rural environmental, with scarce records in protected areas (Klem 2008, Gelb and Delacretaz 2009). In connection, Important Bird Areas (IBAs) represent a global network of relevant sites for the conservation birds and biodiversity. Worldwide, 12,000 sites have been identified and, in Brazil, 234 IBAs were mapped, involving endemic and extreme important localities (Develey and Goerck 2009, Birdlife International 2014). Several problems have been reported regarding human interference in areas devoted for conservationist effort (Lima *et al.* 2005, Rylands and Brandon 2005) and some them is represented by bird collisions.

In this work, our aims were register new species that suffers collisions on windows in a Brazilian reserve and IBA, the RPPN Santuário do Caraça and, evaluate the representativeness of forest dependence, wing types and others characteristics in these specimens. Also, we checked if there is any seasonal relationship, between the dry and rainy seasons and the number of dead birds on site.

Methods

Study area

The Reserva Particular do Patrimônio Natural da Serra do Caraça (RPPN Santuário do Caraça) (20º05’51”S 43º29’18”W; altitude 1,290 m), located between the municipalities of Catas Altas and Santa Bárbara, Minas Gerais State, southeastern Brazil, is a private reserve of 11,233 ha (Santuário do Caraça 2013), located in Quadrilátero Ferrífero and in southern portion of the Espinhaço Range (Figure 1). The region lies in the Atlantic Forest domain, close to the Cerrado domain, two world hotspots of biodiversity (Myers *et al.* 2000, Vasconcelos 2000). The area is inserted in an IBA (BR145) (Birdlife International 2009, 2012, Develey and Goerck 2009), in an Endemic Bird Area (EBA 073) (Stattersfield *et al.* 1998) and in a Biosphere Reserve (UNESCO 2005).

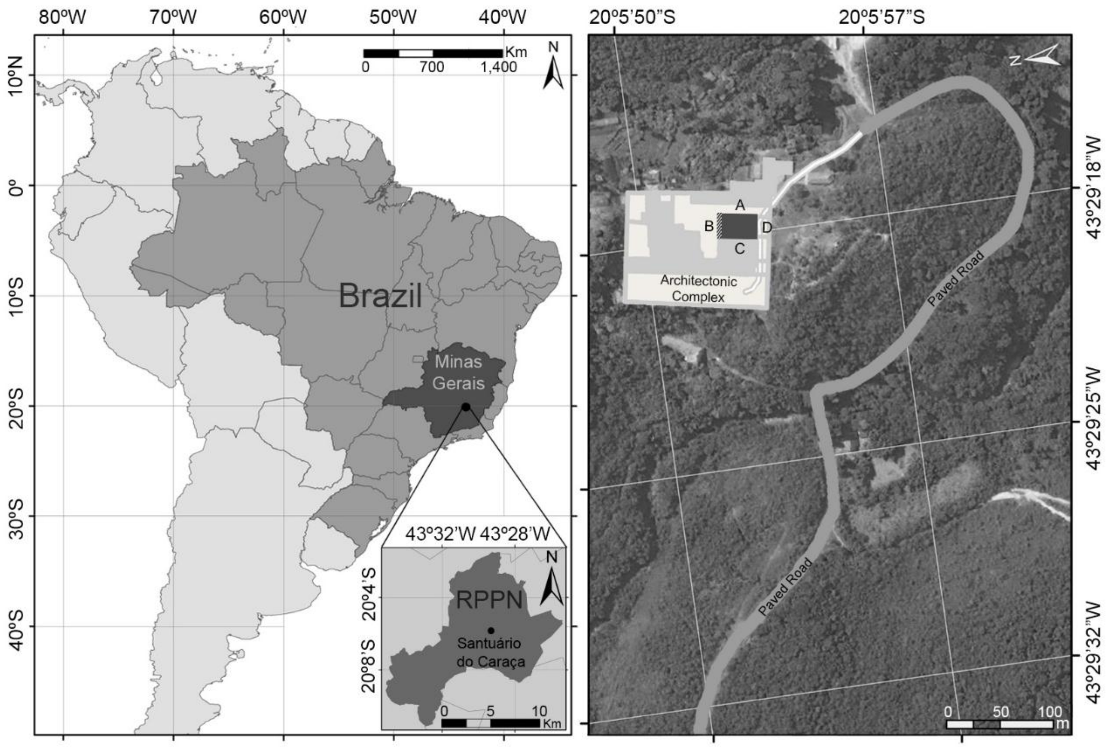

Figure 1. Localization maps and aerial image of RPPN Santuário do Caraça displaying the anthropogenic area with the architectonic complex (Dark gray box is the Museu do Caraça with the sides A-D of windows).

Climate of the RPPN Santuário do Caraça is well defined, with a dry (April to September) and a rainy (October to March) seasons, with mild annual mean temperatures (18-19°C) and lower (0°C or less) temperatures mainly in higher altitudes (Dutra *et al.* 2002). The Köppen-Geiger climatological classification defined this area as Cwb (humid temperate climate with dry winter and temperate summer, similar to tropical climate of altitude) (Alvares *et al.* 2014) and the annual average rainfall it is above 1,500 mm.

The area shelters 372 birds species, including threatened species, 75 migrants, 74 Atlantic Forest endemics, four Cerrado endemics and four species restricted to southeastern Brazilian mountain-tops (Chesser 1994, Vasconcelos 2013). Holding one of the richest in avifaunas of eastern Brazil, the Serra do Caraça is a relevant area for bird conservation, in regional and global scales (Vasconcelos and Melo-Júnior 2001, Bencke *et al.* 2006, Develey and Goerck 2009).

Proceedings and Data Collection

The reserve is well-known for its complex architectonic man-made edifications. One of them is the Museu do Caraça (Figure 1), constituted by large reflective and tempered glass windows (Figure 2), where the collisions occurred. Some cases of roadkills were recorded on the paved road (13 km) which access the edifications of the RPPN (see Figure 1), but these are not included in analyses.

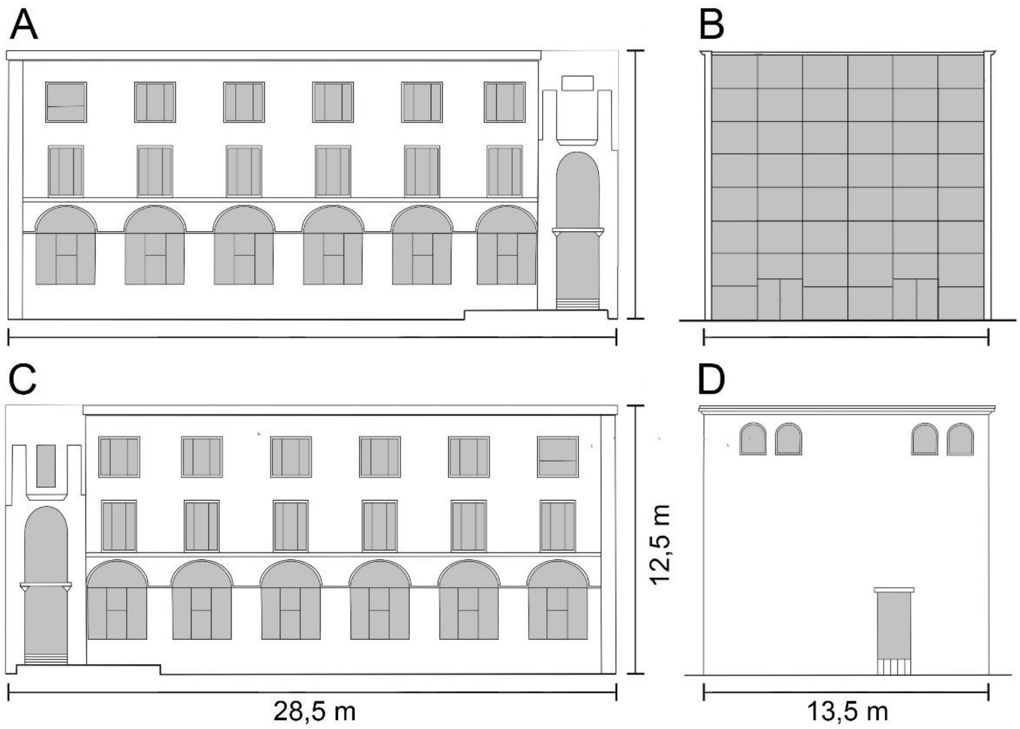

Figure 2. Architectural sketch of Museu do Caraça, showing the details of edification and the measures of width, height and depth of the wall sides. Glass (gray areas) percentage and area (in m²) in each side: A) ≅31% (110); B) ≅90% (151,5); C) ≅34,9% (124,2); D) 13,6% (22,8).

Dead birds were collected daily with the assistance of an environmental team of the reserve during 2010 to 2013. Nonsystematic casual records were made since 2000-2009 and 2014-2015. Each individual was inserted on a plastic bag, which was frozen.

The specimens were taken to the following collections: Museu de Ciências Naturais da Pontifícia Universidade Católica de Minas Gerais (MCN PUC Minas), Department of Zoology of the Universidade Federal de Minas Gerais (DZUFMG) and Museu de Zoologia da Universidade de São Paulo (MZUSP). We identified all indivuduals to species level (CBRO 2015) and most of them were deposited in these scientific collections, as study skins or skeletons.

Data analysis

We conducted qualitative and quantitative classification of the specimens and analyze the natural history and conservation characteristics, following specific literature: I) Forest dependence (Silva 1995): 1) independents (species that occur in open vegetation), 2) semi-dependents (species that occur in open vegetation and forest), and 3) dependents (species found mainly in forest habitats); II) Wing types (Scott and Mcfarland 2010): 1) elliptical, 2) game bird, 3) high-aspect ratio, 4) high-speed, and 5) slotted high-lift; III) Conservation status: global (IUCN 2015), national (MMA 2014a, b) and state (COPAM 2010) levels: Least Concern (LC), Near Threatened (NT), Vulnerable (VU), Endangered (EN), and Critically Endangered (CR); IV) Endemism: for Cerrado (Silva 1995), Atlantic Forest (Brooks *et al.* 1999) and mountaintops of eastern Brazil (Vasconcelos 2008) and; V) Migration: austral migrants (sensu Chesser 1994).

Statistical analyses were conducted in R Software (R Core Team 2015). Plotrix package v.3.6-1 (Lemon *et al*. 2015) was employed for production the radial graph. The analysis (α=0.05) was made for all collided birds on the windows of Museu do Caraça.

To test which categories of forest dependence and wing types, separately, was more representatives in collided birds we use Chi-Square for equal expected proportions. In addition, the Partition Likelihood Ratio Chi-Square was performed for evaluate the relationship of categories between both characteristics.

For test the difference in the number of birds died between the two seasons (dry and rainy) we used the Shapiro-Wilk for normality and, subsequently, the t-Test for two independent samples (parametric). The F-Test was used to compare sample distributions during different seasons. We perform seasonality analyzes only with individuals who have been registered with the month of their collision.

We took the rainfall index (in mm) for each month during 2010-2013 of RPPN and check the difference of the pluviosity for each season, using factorial ANOVA. Posteriorly, to evaluate the rain such as a relevant factor for bird mortality the Pearson Product Moment Correlation was performed, addressing the average rainfall index in these years with the numbers of individuals found dead in each month.

Results

A total of 168 specimens of 57 species (Appendix 1) were found dead by collisions in Museu do Caraça. A rate of mortality of ≅2.12 individual/deaths/month and 25.5 individual/deaths/year between the period of systematic collection (102 individuals in 2010-2013) was obtained. Is valid report three specimens that were roadkilled (Band-winged Nightjar *Hydropsalis longirostris*, Scissor-tailed Nightjar *H. torquata* and Green-winged Saltator *Saltator similis*) in paved road of access to Santuário do Caraça.

Taxa most affected by collisions were the families Columbidae (n=44 individuals), Thraupidae (n=35), Trochilidae (n=16), and Hirundinidae (n=15); genera *Turdus* spp. (n=13) and *Tangara* spp. (n=11) and the following species: Plumbeous Pigeon *Patagioenas plumbea* (n=35 individuals) and Blue-and-white Swallow *Pygochelidon cyanoleuca* (n=13). We describe the numbers of individuals in each order for their categories of forest dependence and wing types (Table 1).

We found higher values of mortality for forests dependent species (n=81; 48.2%) and semi-dependent (n=55; 32.7%), while independent (n=32; 19.1%) obtained lower value. The first category show greater influence on bird mortality (χ^2=21.464; p<0.0001).

Species classified with elliptical wings were most affected (n=133; 79.2%), followed by high-speed (n=32; 19%), game bird (n=2, 1.2%) and slotted high-lift (n=1; 0.6%). A significant difference for those species with elliptical wing in relation to others categories was found (χ^2=277.667; p<0.0001). High-aspect was not found for collided birds, but roadkilled *Hydropsalis* spp. was classified in this category.

Table 1. Orders of collided birds and the number of individuals for each category evaluated of natural history characteristics.

	Galiiformes	Accipritiformes	Columbiformes	Psitaciformes	Apodiformes	Coraciiformes	Piciformes	Passeriformes	Total
Dependent	0	1	41	0	5	0	0	34	81
Semi-dependent	2	0	3	1	10	1	1	37	55
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

The results obtained by interaction of both natural history characteristics showed a significant general value (Table 2). A significant difference was found for Partition one (rows 2: columns 2) (χ^2=4.7271; p=0.0297) and four (rows 2: column 3) (χ^2=24.1172; p<0.0001), corroborating that individuals classified such dependent and elliptical wings are most affected by collisions.

Table 2. Number of individuals dead by collisions classified in interaction categories between forest dependence and wing types.

Categories	Dependent	Semi-dependent	Independent
Elliptical	76	41	16
High-speed	5	11	16
Game bird	0	2	0
Slotted high-lift	0	1	0
Chi-square value			35.1200
Significance level			p<0.0001

In relation to conservation status, only two species were considered globally NT: the Hyacinth Visorbearer *Augastes scutatus* (n=1) and the Swallow-tailed Cotinga *Phibalura flavirostris* (n=2); the last one is also considered Vulnerable in Minas Gerais state. The other specimens were classified as LC in global, national and/or state levels.

Endemic species were represented by 38 specimens from Atlantic Rain Forest and one (Hyacinth Visorbearer) from eastern Brazilian mountains. Also, 27 individuals of 10 species of austral migrants were affected by collisions along our study.

None significant mortality pattern was found between rainy (n=44) and dry (n=54) seasons (t=0.9552; p=0.362; F=1.0147; p=0.9876) (Figure 4). The significant difference of rainfall index between the seasons (F(seasons)=37.4398; p<0.0001) was not correlated with bird mortality (Figure 3).

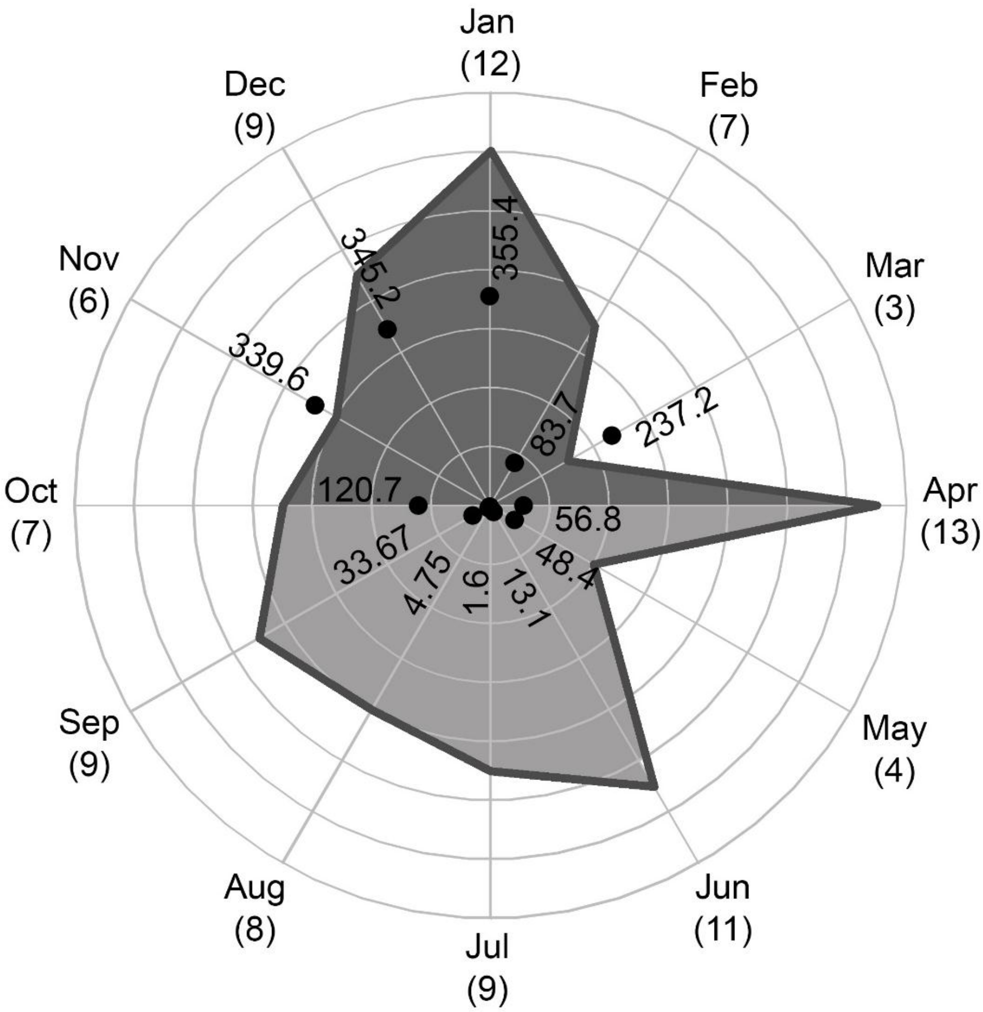

Figure 3. Radial graph of average of individuals found dead in each month of two seasons of study (polygon) (light gray: dry season; dark gray: rainy season; grid scale: 0-14). Data points (in black) and respectively numbers reveal the average value (mm) of 2010-2013 years of rainfall indexes in Caraça reserve (grid scale: 0-700).

Discussion

Was recorded 15.86% of the total species known to occur in the RPPN that died by collisions. However, it is important to stress that, even with the helpful assistance of the environmental team of Caraça reserve, it is possible that several dead specimens were overlooked. This occurs because of the fast deterioration caused by natural factors such as weather, sunlight, rain, necrophilous animals (ants, mosquitoes, beetles) and others biological agents (bacterial digestion) (Crawford 1971, Balcomb 1986, Pain 1991, Wobeser and Wobeser 1992). Scavengers and opportunists predators can take advantage of small birds carcasses within a few minutes, which implies that most of studies on mortality of birds by human factors are underestimated, mainly in roadkills works (Morris 2002, Antworth *et al.* 2005).

The three roadkilled specimens are commonly found in open areas and forest edges and the Band-winged Nightjar and Scissor-tailed Nightjar are nocturnal and insectivorous birds, being observed often in roads searching insects (Sick 1997). The risk of roadkills can be higher in species with this behaviour (Erritzoe *et al.* 2003).

Forest dependence birds were most affected by collisions in RPPN. We interpret those anthropic constructions, for example of the Museu do Caraça, interrupt the natural corridor formed by the vegetation in their surroundings and forest birds cannot recognize these obstacles as a change of habitat. In contrast, the lowest number of independent forest species can be associate with the capacity of recognize edges in open areas and they would have a broader movement and greater perception of obstacles, being able to deviate and are not as affected by anthropic constructions. Notwithstanding, the cases on specimens classified as semi-dependent were also relevant, such as the family Thraupidae, especially *Tangara* spp., and some species of Trochilidae.

Forest dependent species reacts more negatively to changes in the environments than independent, for example the presence of forests next to roads increased the roadkills in forest species (Marini 2001, Ramos *et al.* 2011). Although it is known that forest birds avoid crossing open areas of large extension (Grubb and Doherty 1999, Develey and Stouffer 2001), these species perform frequent movements in their environments and can cross forest fragments, mainly those are adapted to patches (Marini 2001, Yabe et al. 2010).

However, the high incidence of Columbidae individuals, especially the Plumbeous Pigeon, influenced significantly the interpretation of our analysis. Perhaps the abundance of this specie in reserve and the patterns of his biological activities, such feeding, displacement and reproduction, determined its high collision rate. In conjunction, the abundance and the differential use of specific habitats of bird populations in localities it is fundamental to predict the collisions (De Lucas *et al.*, 2008, Marques *et al.* 2014).

Different wing types are associated with different modes of flight performance (Warham 1977, Copete 1999). In power lines, the flight behaviour is one of the most important biological features for bird collisions (Bevanger 1994, Janss 2000).

The prominent incidences of birds with elliptical wings indicated this characteristic how the most subject to collisions. Scott and McFarland (2010) explains the elliptical characteristics as quick bursts of speed and species with these wing types are adept in densely vegetated habitats. This fact contextualizes the representativeness of this category in our sample, especially due to the proximity of vegetation in the Museu do Caraça. In addition, Passeriformes, following by Columbiformes, was the order more represented on totality of collided individuals and in elliptical wings category and both groups shows relevant association with vegetation.

High-speed birds were represented here by some species of Trochilidae and Hirundinidae. This wing type can be associated with fast flights and birds staying longer in flight (Scott and Mcfarland 2010). Including, Sporer et al. (2013) checked high-speed and elliptical birds are relevantly affected by collisions in power lines Jenkins et al. (2010) appoint that greater speeds affects the reaction time of birds to avoid collisions in anthropic structures. Game birds, slotted and high aspect wing types was not expressive in our samples and they are also related with other with other flight performances as soar, lift and difficult takeoff.

The frequency of collisions in the edifications with large windows can be evaluated by the landscape around their surroundings and the reflections of exterior vegetation (Ogden 1996, Gelb and Delacretaz 2006, 2009, Klem 2009). It is noteworthy that the Museu do Caraça are nearby to a large area of vegetation, but in an open area inside the architectonic complex. Sensory analyzes explains that birds perceive these reflections as an expansion of physical environment and their visual system is not dedicated exclusively to perception of fixed obstacles, such human artifacts, thus colliding eventually against the windows (Martin and Shaw 2010, Martin 2011).

Our data did not show any seasonal significant difference on bird mortality between dry and rainy seasons and any correlation between mortality and rainfall index. Wide variations in the monthly rainfall indexes are found in Caraça reserve, but slight oscillations for other factors such as temperature, speed and wind direction have already been checked (Moreira and Pereira 2013). Bird collisions by artificial structures related to seasonal patterns can be aggravated in regions where the weather and climate conditions present greater variations, having also connection with routes and coming of other types of migrants species (e.g., Borden *et al*. 2010, Klem 1989).

Other weather conditions and meteorological aspects, as daily temperature, air humidity, sunlight, clouds and mist, changes the bird interaction and perception of physical environmental (e.g., Bevanger 1994, Drewitt and Langston 2008, Martin 2011). To Neotropical region, the influence of these conditions is still unknown on bird collisions and could have other environmental factors shaping this interaction. Explore seasonal patterns may promote fundamental answers in bird collisions, providing important information and strategies for solve this problem (Calvin *et al*. 2010).

It is important to stress that not all bird species are equally susceptible to mortality by collisions (Bevanger 1994, Drewitt and Langston 2008, Loss *et al.* 2014). Borden *et al.* (2010) add that collisions are a complex question and there are no simple relationships to understand this issue in its entirety. Besides, taking the example of changes in height of flight and routes of migratory species, other behaviour and ecology relations of species it may happen in function to human changes in nature.

Our data can be useful to prevent futures negatives impacts on avifauna of several rainforests areas with the establishment of similar constructions as Museu do Caraça, a common model of building (edifications with large windows next to forest areas) present in a many localities of Brazil, like Serra da Mantiqueira (Vasconcelos and D'Angelo-Neto 2009). Further, we can base more characteristics of natural history and ecology, like wings biometry, speed/distance in flight and comparative optical system, as well integrate species survey, population dynamics and abundance data in analyses, to turn stronger the studies and prediction of collisions.

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References

ACS - Assessoria de Comunicação Social da Universidade de Brasília. (2006) Prédio espelhado atrai pássaros para a morte. Jornal de Brasília. <http://www.secom.unb.br/unbcliping2/2006/cp060306-12.htm>.

Alvares, C. A., Stape, J. L., Sentelhas, P. C., Gonçalves, J. L. M. and Sparovek, G. (2013) Köppen's climate classification map for Brazil. *Meteorologische Zeitschrift*. 22 (6): 711-728.

APLIC - Avian Power Line Interaction Committee. (2012) Reducing avian collisions with power lines: the state of the art in 2012. Edison Electric Institute and Avian Power Line Interaction Committee, Washington, D.C., USA.

Avery, M. L. (1979) *Review of avian mortality due to collisions with manmade structures*. Lincoln, University of Nebraska: Wildlife Damage Management Internet Center for Bird Control Seminars Proceedings.

Avery, M. L., Springer, P. F. and Dailey, N. S. (1978) *Avian mortality at man-made structures: as annotated bibliography*. U.S. Department of the Interior. Fish and Wildlife Service. FWS/OBS-78/58.

Antworth, R. L., Pike, D. A. and Stevens, E. E. (2005) Hit and run: effects of scavenging on estimates of roadkilled vertebrates. *Southeastern Naturalist*. 4 (4): 647-656.

Balcomb, R. (1986) Songbird carcasses disappear rapidly from agricultural fields. *The Auk*. 103 (4) 817-820.

Banks, R. C. (1979) *Human related mortality of birds in the United States*. United States Department of the Interior - Fish and Wildlife Services. Special Scientific Report - Wildlife, n. 215, Washington, D.C.

Bencke, G. A., Maurício, G. N., Develey, P. F. and Goerck, J. M. (2006) Áreas importantes para a conservação das aves no Brasil: Parte I - Estados do Domínio da Mata Atlântica. *Revista Brasileira de Ornitologia*. 14 (2): 169-170.

Bevanger, K. (1994) Bird interactions with utility structures: collision and electrocution, causes and mitigating measures. *IBIS*. 7: 412-425.

Birdlife International. (2009) *Important Bird Areas (IBA's)*. < http://www.birdlife.org/action/science/sit-es/>.

Birdlife International. (2012) *State of the world's birds: indicators for our changing planet*. Cambridge, UK: BirdLife International.

BirdLife International (2014) Important Bird and Biodiversity Areas: A global network for conserving nature and benefiting people. Cambridge, UK: BirdLife International.

Borden, W. C., Lockhart, O. M., Jones, A. W. and Lyons, M. S. (2010) Seasonal, Taxonomic, and Local Habitat Components of Bird-window Collisions on an Urban University Campus in Cleveland, OH. *The Ohio Journal of Science*. 110 (3): 44-52.

Brooks, T., Tobias, J. T. and Balmford, A. (1999) Deforestation and bird extinctions in the Atlantic forest. *Animal Conservation*. 2: 211-222.

Calvin, B. W., Lockart, O. M., Jones, A. W. and Lyons, M. S. (2010) Seasonal, Taxonomic, and Local Habitat Components of Bird-window Collisions on an Urban University Campus in Cleveland, OH. *The Ohio Journal of Science*. 110 (3): 44-52.

Carrano, E. (2006) *Composição e conservação da avifauna na Floresta Estadual do Palmito, município de Paranaguá, Paraná*. Dissertação de Mestrado, Universidade Federal do Paraná, Pós-graduação em Engenharia Florestal, 125p.

CBRO - Comitê Brasileiro de Registros Ornitológicos. (2015) *In*: Piacentini, V. Q., Aleixo, A., Agne C. E., Maurício, G. N., Pacheco, J. F., Bravo, G. A., Brito, G. R. R., Naka, L. N., Olmos, F., Posso, S., Silveira, L. F., Betini, G. S., Carrano, E., Franz, I., Lees, A. C., Lima, L. M., Piolo, D., Schunck, F., Amaral, F. R., Bencke, G. A., Cohn-Haft, M., Figueiredo, L. F. A., Straube, F. C. and Cesari E. Annotated checklist of the birds of Brazil by the Brazilian Ornithological Records Committee. *Revista Brasileira de Ornitologia*. 23 (2): 91-298.

Corre, N. L., Gélinaud, G. and Brigand, L. (2009) Bird disturbance on conservation sites in Brittany (France): the standpoint of geographers. *Journal of Coastal Conservation*. 13: 109-118.

Chesser, R. T. (1994) Migration in South America: an overview of the austral system. *Bird Conservation International*. 4: 91-107.

COPAM - Conselho Estadual de Política Ambiental. (2010) *Lista de Espécies Ameaçadas de Extinção da Fauna do Estado de Minas Gerais*. Deliberação Normativa COPAM, no. 147, de 30 de abril de 2010.

Copete, J. L., Mariné, R., Bigas, D. and Vilalta, A. M. (1999) Differences in wing shape between sedentary and migratory Reed Buntings Emberiza schoeniclus. *Bird Study*. 46: 100-103.

Crawford, R. L. (1971) Predation on birds killed at TV tower. *Oriole*. 36(4): 33-35.

De Lucas, M., Janss, G. F. E., Whitfield, D. P. and Ferrer, M. (2008) Collision fatality of raptors in wind farms does not depend on raptor abundance. *Journal of Applied Ecology*. 45, 1695-1703.

Develey, P. F. and Goerck, J. M. (2009) Important Bird Areas Americas: Brazil. *In*: Devenish. C., Fernandez, D. F. D., Clay, R. P., Davison, I. and Zabala, I. Y. *Important Bird Areas Americas - Priority sites for biodiversity conservation*. Quito, Ecuador: BirdLife International (BirdLife Conservation Series), (16): 99-112.

Develey, P. F. and Stouffer, P. C. (2001) Effects of roads on movements by understory birds in mixed-species flocks in Central Amazonian Brazil. *Conservation Biology*. 15 (5): 1416-1422.

Diehl, R. H., Bates, J. M., Willard, D. E. and Gnoske, T. P. (2014) Bird mortality during noctural migration over Lake Michigan: a case study. *The Wilson Journal of Ornithology*. 126 (1):19-29.

Drewitt, A. L. and Langston, R. H. W. (2006) Assessing the impacts of wind farms on birds. *IBIS*. 148: 29-42.

Drewitt, A. L. and Langston, R. H. W. (2008) Collision Effects of Wind-power Generators and Other Obstacles on Birds. *Annals of the New York Academy of Sciences*. 1134: 233-266.

Dutra, G. M., Rubbioli, E. L. and Horta, L. S. (2002) Gruta do Centenário, Pico do Inficionado (Serra do Caraça), MG: A maior e mais profunda caverna quartzítica do mundo. Parte 7: Sítios Geológicos. *In:* Schobbenhaus, C., Campos, D. A., Queiroz, E. T., Winge, M. and Berbert-born, M. *Sítios Geológicos e Paleontológicos do Brasil*. DNPM/CPRM - SIGEP, Brasília. 1: 431-441.

Erickson, W. P., Johnson, G. D., Strickland, M. D., Young, Júnior. D. P., Sernka, K. J. and Good, R. E. (2001) *Avian Collisions with Wind Turbines: A Summary of Existing Studies and Comparisons to Other Sources of Avian Collision Mortality in the United States*. National Wind Coordinating Committee (NWCC) Resource Document.

Erickson, W. P., Johnson, G. D. and Young Júnior, D. P. (2005) *A summary and comparison of bird mortality from anthropogenic causes with an emphasis on collisions*. USDA Forest Service General Technical Report. 191: 1029-1042.

Erritzoe, J., Mazgajski, T. D. and Rejt, L. (2003) Bird casualties on European roads - a review. *Acta Ornithologica*. 38 (2): 77-93.

Gabrey, S. W. and Dolbeer, R. A. (1996) Rainfall effects on bird-aircraft collisions at two United States airports. *Wildlife Society Bulletin*. 24: 272-275.

Gelb, Y. and Delacretaz, N. (2006) *Windows and Vegetation: primary factors in manhattan bird collisions*. RRH: Manhattan Bird Collisions.

Gelb, Y. and Delacretaz, N. (2009) Windows and Vegetation: Primary Factors in Manhattan Bird Collisions. *Northeastern Naturalist*. 16 (3): 455-470.

Grubb, T. C. and Doherty, Jr., P. F. (1999) On home-range gap-crossing. *Auk*. 116: 618-628.

Hager, S. B., Trudell, H., Mckay, K. J., Crandall, S. M. and Mayer, L. (2008) Bird density and mortality at windows. *The Wilson Journal of Ornithology*. 120 (3): 550-564.

IUCN. (2015) *IUCN red list of threatened species*. < www.iucnredlist.org>.

Janss, G. F. E. (2000) Avian mortality from power lines: a morphologic approach of a species-specific mortality. *Biology Conservation*. 95: 353-359.

Jenkins, A. R., Smallie, J. J. and Diamond, M. (2010) Avian collisions with power lines: a global review of causes and mitigation with a South African perspective. *Bird Conservation International*. 20: 263-278.

Johnson, G. D., Erickson, W. P., Strickland, M. D., Shepherd, M. F., Sheperd, D. A. and Sarappo, A. S. (2002) Collision Mortality of Local and Migrant Birds at a Large-Scale Wind-Power Development on Buffalo Ridge, Minnesota. *Wildlife Society Bulletin*. (3): 879-887.

Klem JR. D. (1989) Bird: Window Collisions. *The Wilson Bulletin*. 101 (4): 606-620.

Klem JR. D. (1990a) Bird Injuries, Cause of Death, and Recuperation from Collisions with Windows (Heridas,Causas de Muerte y Restablecimiento de Aves que Chocan con Ventanas). *Journal of Field Ornithology*. 61 (1): 115-119.

Klem, JR. D. (1990b) Collisions between Birds and Windows: Mortality and Prevention (Colisiones de Pájaros con Ventanas: Mortalidad y Prevención). *Journal of Field Ornithology*. 61 (1): 120-128.

Klem JR. D. (2008) Avian mortality at windows: the second largest human source of bird mortality on earth. *Proceedings of the Fourth International Partners in Flight Conference: Tundra to Tropics*. 244-251.

Klem, JR. D. (2009) Preventing Bird-Window Collisions. *The Wilson Journal of Ornithology*. 121 (2): 314-321.

Laurance, W. F., Goosem, M. and Laurance, G. W. (2009) Impacts of roads and linear clearings on tropical forests. *Trends in Ecology and Evolution*. 24 (12): 659-669.

Leddy, K. L., Higgins, K. F. and Naugle, D. E. (1999) Effects of Wind Turbines on Upland Nesting Birds in Conservation Reserve Program Grasslands. *The Wilson Bulletin*. 111 (1): 100-104.

Lemon, J., Bolker, B., Oom, S., Klein, E., Rowlingson, B., Wickman, H., Tyagia A., Eteradossi, O., Grothendieck, G., Toews, M., Kane, J., Turner, R., Witthoft, C., Stander, J., Petzoldt, T., Duursma, R., Biancotto, E., Levy, O., Dutang, C., Solymos P., Engelmann, R., Hecker, M., Steinbeck, F., Borchers, H., Singmann, H., Toal, T. and Ogle, D. (2015) Package '*plotrix': Various Plotting Functions*, The Comprehensive R Archive Network.

Lima, G. S., Ribeiro, G. A. and Gonçalves, W. (2005) Avaliação da efetividade de manejo das unidades de conservação de proteção integral em Minas Gerais. *Revista Árvore*. 29 (4): 647-653.

Loss, S. R., Will, T. and Marra, P. (2012) Direct human-caused mortality of birds: improving quantification of magnitude and assesment of populaton impact. *Frontiers in Ecology and the Environment*. 10 (7): 357-364.

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

Maldonado-Coelho, M. and Marini, M. A. (2003) Composição de bandos mistos de aves em fragmentos de mata atlântica no sudeste do Brasil. *Papéis Avulsos de Zoologia*. 43 (3): 31-54.

Manville, A. M. (2001) Avian mortality at communication towers: steps to alleviate a growing problem. In: Levitt, B. B. *Cell towers - wireless convenience? Or environmental hazard? Proceedings of the "Cell Towers Forum," state of the science/state of the law*. Markham, Ontario: New Century. 75-86.

Marques, A. T., Batalha, H., Rodrigues, S., Costa, H., Pereira, M. J. R., Fonseca, C., Mascarenhas, M. and Bernardinho, J. (2014) Understanding bird collisions at wind farms: An updated review on the causes and possible mitigation strategies. *Biological Conservation*. 179: 40-52.

Marini, M. A. (2001) Effects of forest fragmentation on birds of the Cerrado region, Brazil. *Bird Conservation International*. 11: 13-25.

Martin, G. R. (2011) Understanding bird collisions with man-made objects: a sensory ecology approach. *IBIS - The International Journal of Avian Science*. 153: 239-254.

Martin, G. R. and Shaw, J. M. (2010) Bird collisions with power lines: Failing to see the way ahead? *Biological Conservation*. 143: 2695-2702.

MMA - Ministério do Meio Ambiente, Instituto Chico Mendes de Conservação de Biodiversidade (ICMBio). (2014a) *Lista Nacional Oficial de Espécies da Fauna Ameaçadas de Extinção*. Portaria no. 444, de 17 de dezembro de 2014.

MMA - Ministério do Meio Ambiente, Instituto Chico Mendes de Conservação de Biodiversidade (ICMBio). (2014b) *Lista das espécies da fauna brasileira consideradas Quase Ameaçadas (NT)*. Portaria MMA no. 43, de 31 de janeiro de 2014.

Moreira, A. A. M. and Pereira, C. C. A. (2013) Clima. *In:* Santuário do Caraça. *Plano de manejo da RPPN "Santuário do Caraça"*. Província Brasileira da Congregação da Missão. Catas Altas/Santa Bárbara, Minas Gerais. 195p.

Morrinson, M. L. (1998) *Avian risk and fatality protocol*. USA, Golden, National Renewable Energy Laboratory, NREL/SR-500-24997.

Morris, M. (2002) Grill bird alert. Parks Canada. (Brochure on avoiding birds attracted to highways by salt and sand.)

Muhlenberg Colege. (2009) *Brazil - 41 Species documented to have collided with sheet glass or plastic*. Acopian Center for Ornithology. <http://www.muhlenberg.edu/main/academics/biology/acopiancenterfo-rornithology/brazil/>.

Myers, N., Mittermeier, R. A., Mittermeier, C. G, Fonseca, G. A. B. and Kent, J. (2000) Biodiversity hotspots for conservation priorities. *Nature*. 403 (24): 853-858.

Nascimento, I. L. S., Neto, A. S., Alves, V. S., Maia, M., Efe , M. A., Telino Júnior, W. R. and Amaral, M. F. (2005) Diagnóstico da situação nacional de Colisões de aves com Aeronaves. *Ornithologia*. 1 (1): 93-104.

Ogden, L. E. (1996) *Collision courses: The hazards of lighted structures and windows to migrant birds*. Fatal Light Awareness Program (FLAP). Paper 3.

Pain, D. J. (1991) Why are lead-poisoned waterfowl rarely seen?: The disappearance of waterfowl carcasses in the Camargue, France. *Wildfowl*. 42: 118-122.

Piorkowski, M. D. (2006) *Breeding bird habitat use and turbine collisions of birds and bats located at a wind farm in Oklhaoma mixed-grass prairie*. 102f. Master of Science - The Pennsylvania State University, State College, Pennsylvania.

R Core Team, 2015. *R: A language and environment for statistical computing*. R Foundation for Statistical Computing, Vienna, Austria. < http://www.R-project.org/>.

Ramos, C. C. O., Lima Júnior, D. P., Zawadki, C. H. and Benedito, E. (2011) The biology and ecology of birds is an important factor for explain the road kill frequencies? *Neotropical Biology and Conservation*. 6 (3): 201-212.

Roma, J. C. (2006) *A fragmentação e seus efeitos sobre as aves de fitofisionomias abertas do Cerrado*. 210f. Tese (Doutorado em Ecologia) - Universidade de Brasília, Programa de Pós-graduação em Ecologia, Brasília.

Rosa, C. A. and Bager, A. (2012) Seasonality and habitat types affect roadkill of neotropical birds. *Journal of Environmental Management*. 97: 1-5.

Rybak, E. J., Jackson, W. B. and Vessey, S. H. (1973) Impact of cooling towers on bird migration. *Bird Control Seminars Proceedings*. 120: 187-194.

Ryder, T. B., Fleischer, R. C., Shriver, W. G., Marra, P. P. (2012) The ecological-evolutionary interplay: density-dependent sexual selection in a migratory songbird. *Ecology and Evolution*. 2 (5): 976-987.

Rylands, A. B. and Brandon, K. (2005) Unidades de conservação brasileiras. *Megadiversidade*. 1 (1): 27-35.

Santos, T. M., Cunha, J. G. and Monteiro, A. R. (2011) *Utilização de silhuetas para minimizar e/ou evitar, colisão de aves sobre as vidraças na passarela do Instituto de Pesquisa e Desenvolvimento - IP&D em São José dos Campos, SP/Brasil*. *In*: X Encontro Latino Americano de Pós-Graduação, São José dos Campos, Brasil.

Santuário do Caraça. (2013) Plano de manejo da RPPN "Santuário do Caraça". Província Brasileira da Congregação da Missão. Catas Altas/Santa Bárbara, Minas Gerais. 195p.

Scott, S. D. and C. McFarland. (2010) *Bird feathers: a guide to North American species*. Stackpole, Mechanicsburg, Pennsylvania, USA.

Sick, H. (1997) *Ornitologia Brasileira*. Rio de Janeiro, Brasil: Editora Nova Fronteira.

Silva, J. M. C. (1995) Birds of the Cerrado Region, South America. *Steenstrupia*. 21: 69-92.

Soares, P. K. R., Portugal, G. C., Costa, M. C., Uzai, L. M. S., Gonçalves, N. C., Teixeira, J. P. G., Diniz, G. P., Souza, A. Z. and Ribon, R. (2011) *Bird collisions against buildings at the Universidade Federal de Viçosa, Viçosa, Minas Gerais, Brazil*. *In*: IX Congresso de Ornitología Neotropical, Cusco, Peru.

Sporer, M. K., Dwyer, J. F., Gerber, B. D., Harness, R. E. and Pandey, A. K. (2013) Marking Power Lines to Reduce Avian Collisions Near the Audubon National Wildlife Refuge, North Dakota. *Wildlife Society Bulletin*. 37 (4): 796-804.

Stattersfield, A. J., Crosby, M. J., Long, A. J. and Wege, D. C. (1998*) Endemic Bird Areas of the world: Priorities for Biodiversity Conservation*. UK, Smithsonian: BirdLife International (BirdLife Conservation Series). (7): 864 p.

Steele, W. K. (2001) Factors Influencing the Incidence of Birds-Strikes at Melbourne Airport, 1986-2000. *Bird Strike Committee Proceedings*, USA/Canada, Third Joint Annual Meeting, Calgary, AB. Paper 24.

Stolk, A. S., Girelli, C., Miguel, L. P., Benedet, G. and Cascaes, M. (2015) Avifauna collision on glass fronts of a urban area in Balneário Rincão, Santa Catarina. *Revista Tecnologia e Ambiente.* 21 (1): 249-263.

UNESCO - Organização das Nações Unidas Para a Educação, a Ciência e a Cultura. (2005) *UNESCO reconhece nova reserva da Biosfera no Brasil: Serra do Espinhaço*, MG.

Vasconcelos, M. F. (2000) Reserva do Caraça: história, vegetação e fauna. *Aves*. 1 (1): 3-7.

Vasconcelos, M. F. (2008) Mountaintop endemism in eastern Brazil: why some bird species from campos rupestres of the Espinhaço Range are not endemic to the Cerrado region? *Revista Brasileira de Ornitologia*. 16: 348-362.

Vasconcelos, M. F. (2013) Avifauna. *In:* Santuário do Caraça. *Plano de manejo da RPPN "Santuário do Caraça"*. Província Brasileira da Congregação da Missão. Catas Altas/Santa Bárbara, Minas Gerais. 195p.

Vasconcelos, M. F. and D'Angelo-Neto, S. (2009) First assessment of the avifauna of Araucaria forests and other habitats from extreme southern Minas Gerais, Serra da Mantiqueira, Brazil, with notes on biogeography and conservation. *Papéis Avulsos de Zoologia*. 49: 49-71.

Vasconcelos, M. F., Melo-Júnior, T. A. (2001) An ornithological survey of Serra do Caraça, Minas Gerais, Brazil. *Cotinga*. 15: 21-31.

Veltri, C. J. and Klem, JR. D. (2005) Comparison of fatal bird injuries from collisions with towers and windows. *Journal of Field Ornithology*. 76 (2): 127-133.

Warham, J. (1977) Wing loadings, wing shapes, and flight capabilities of procellariiformes. *New Zealand Journal of Zoology*. 4 (1): 73-83.

Winkelman, J. E. (1995) Bird/wind turbine investigations in Europe. In: Denver, C. O. *Proceedings of the National Avian-Wind Power Planning Meeting*. Ontario, King City: Environmental Research Associates. 43-47.

Wobeser, G. and Wobeser, A. G. (1992) Carcass disappearance and estimation of mortality in a simulated die-off of small birds. *Journal of Wildlife Diseases*. 28: 548-554.

Yabe, R. S., Eliézer, J. M. and Marini, M. A. (2010) Movements of birds among natural vegetation patches in the Pantanal, Brazil. *Bird Conservation International*. 20: 400-409.

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Appendix 1. List of species found dead due collisions in Museu do Caraça (RPPN Santuário do Caraça) and their respective information.

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 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	S	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	S	HS	LC [G, N, S]	7 (1)
White-vented Violetear *Colibri serrirostris* (Vieillot, 1816)	1	S	HS	LC [G, N, S]	4 (1)

Taxon	Number of individual	Forest Dependence	Wing type	Conservation Status	Seasonality
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	S	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]	
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	S	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	S	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)

Taxon	Number of individual	Forest Dependence	Wing type	Conservation Status	Seasonality
Cotingidae Bonaparte, 1849					
Swallow-tailed Cotinga [M] *Phibalura flavirostris* Vieillot, 1816	2	S	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)
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					

Taxon	Number of individual	Forest Dependence	Wing type	Conservation Status	Seasonality
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	S	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	S	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)