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Notes

Terrestrial mammal and reptile hazards in an airport in the Brazilian Amazon

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Collisions between animals and aircrafts, usually known as wildlife strikes, are a concern for flight safety specialists all over the world. An estimated $1.2 billion in civil aviation losses worldwide have been linked to these events annually (Allan 2002). Wildlife strikes have also been responsible for the destruction of over 500 aircraft and the loss of 505 human lives between 1960 and 2004 (Cleary et al. 2006).

Researchers estimate that 97% of wildlife strikes to aircraft occur with bird species, though terrestrial mammals and reptiles can pose a significant risk due to their size and weight (Dolbeer et al. 2000, DeVault et al. 2011, Biondi et al. 2011, Crain et al. 2015). Most collisions with terrestrial mammals occur inside the airport, usually with species that normally benefit from buildings, airport structures, or the local environment (Cleary et al. 2006). Bodies of water and native vegetation are sometimes present in these environments and can act as a refuge for species such as deer and foxes (Dolbeer et al. 2000, DeVault et al. 2008). The removal or reduction of animal attractants inside the airport is fundamental for wildlife management (Cleary et al. 2006, DeVault et al. 2008).

Elevated species richness for reptiles, mammals, and birds occurs in the Amazon biome, especially in the unflooded forest (Haugaasen and Peres 2005). The city of Manaus is situated where 2 important Amazon tributaries, the Negro and Solimões rivers, merge (Martins and Oliveira 1993, De Oliveira and Daly 1999, Cohn-Haft et al. 1997). Although Manaus is urbanizing, large areas of forest fragments still remain, including at sites surrounding Manaus International Airport (MAO). These urban forest fragments harbor wildlife species, such as wild felines, deer, sloths, anteaters, alligators, anacondas and many others.

In 2010, 10 Brazilian airports, including MAO, implemented a wildlife management program called Fauna in Brazilian Airports. Over the 5-year project, the wildlife management team based at the MAO noticed a high occurrence of collisions involving terrestrial mammals and reptiles. The objective of this study was to determine the incidence of aircraft collisions with terrestrial mammals and reptiles through MAO wildlife strike reports and compare these occurrences with other Brazilian airports. We believed that, although birds cause most collisions in Brazil and globally, a high number of terrestrial mammal and reptile strikes at the

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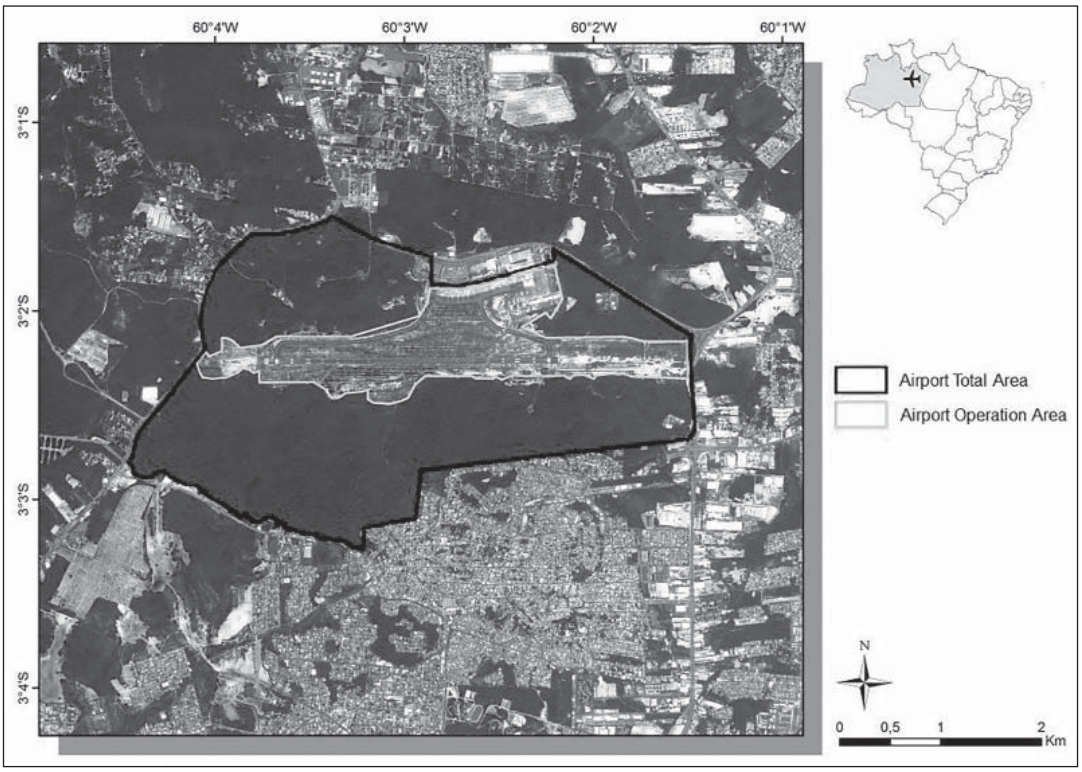

Figure 1. Manaus International Airport area, Amazonas, Brazil. Forest fragments inside the airport area indicated in dark shading.

MAO compared to other airports demanded specific management procedures.

Study area

The Amazon is the largest continuous tropical rainforest in the world. Its 7 million km^2 covers 9 countries in South America (De Miranda and Mattos 1992, Haugaasen and Peres 2005). In Manaus (03°08'S, 60°01'W), the local climate is tropical humid with 2 distinct seasons: rainy from December to May and dry from July to November (Ribeiro 1991). Located in the heart of the Amazon rainforest, MAO covers 1,400 ha, with 981 ha mostly primary and secondary forest (Figure 1). This international airport had over 55,000 operations and 3 million passengers per year between 2010 and 2014 (INFRAERO 2015).

Methods

We reviewed a database of the Centro de Investigação e Prevenção de Acidentes Aeronáuticos (CENIPA), the Brazilian official report center responsible for gathering and publishing nationwide wildlife strike reports. We tabulated the wildlife strike reports for MAO to identify the number of terrestrial mammal and reptile strikes from 2010 to 2014. Additionally, we used the MAO wildlife management team database to identify the main species involved in aircraft strikes because most terrestrial mammal and reptile collisions in the CENIPA database contained only the animal class. We compared the number of strikes at MAO with CENIPA wildlife strike reports from the other 9 airports in the Fauna in Brazilian Airports program. The airports, according to their regions, were as follows: North Region: Belém International Airport, Pará State; Northeast Region: Fortaleza International Airport, Ceará State; Recife International Airport, Pernambuco State; Maceió International Airport, Alagoas State; Salvador International Airport, Bahia State; Central Region: Brasília International Airport, Distrito Federal; Cuiabá International Airport, Mato Grosso State; Southeast Region: São Paulo International Airport, São Paulo State; and Southern Region: Porto Alegre International Airport, Rio Grande do Sul State.

Data involving wildlife strikes were assessed

Table 1. Aircraft–wildlife strikes in 10 Brazilian airports, 2010 to 2014 (CENIPA airport–wildlife strike database).

Airport	Bird + bat strikes	Terrestrial mammal strikes	Reptile strikes	Total
Manaus International Airport	67	15	18	100
Belém International Airport	112	5	5	122
Fortaleza International Airport	94	8	4	106
Recife International Airport	98	3	0	101
Maceió International Airport	37	1	0	38
Salvador International Airport	186	3	7	196
Brasília International Airport	252	8	6	266
Cuiabá International Airport	83	2	5	90
São Paulo International Airport	125	5	2	132
Porto Alegre International Airport	228	7	5	240

with respect to: 1) number of wildlife reports; 2) number of reports concerning only terrestrial mammals and reptiles; 3) proportion of collision reports between aircraft and terrestrial mammals or reptiles; and 4) main species involved in aircraft strikes in the MAO. In the analyses, we used only wildlife strike data with identified animals, at least on class level (birds, mammals or reptiles). We used 1-way ANOVA and post-hoc Tukey tests to evaluate differences in the number of terrestrial mammal and reptile strikes in the MAO and other 9 Brazilian airports.

Results

We identified 150 wildlife strikes between 2010 and 2014 in the MAO. Of these, 100 strikes had the species or animal class identified. In the same period there were 2,592 reported collisions in the 10 airports analyzed, including MAO, where 1,391 collisions included the wildlife species or class identification. In these 10 airports, the collisions with birds/bats represented 92% of the total collisions reported, while terrestrial mammals and reptiles strikes represented 8%. Considering only MAO, the number of collisions involving terrestrial mammals and reptiles represented 33% of total collisions, consisting of 15% terrestrial mammals and 18% reptiles (Table 1). The results indicated differences in the number of collisions involving terrestrial mammals and reptiles among the airports ($F = 7.79$, $df = 9, 90$, $P < 0.001$), and the post-hoc Tukey test indicated that only the strike reports from MAO were different from the others (post-hoc Tukey test, all $P < 0.001$).

According to CENIPA and the MAO wildlife management team databases, 7 species were identified from a total of 33 wildlife strikes. Alligators, including both the smooth-fronted caiman (*Paleosuchus trigonatus*) and the spectacled caiman (*Caiman crocodilus*), had the highest number of collisions, with a total of 8 aircraft strikes. Snakes, mainly represented by boa constrictor (*Boa constrictor*) and green anaconda (*Eunectes murinus*), with 4 aircraft strikes, were the second group with the most occurrences. The black-eared opossum (*Didelphis marsupialis*), with 2 aircraft strikes, the sloth (Pilosa Order), also with 2 collisions, and the lesser anteater (*Tamandua tetradactyla*), with 1 collision, complete the species involved in strike occurrences at the MAO.

Discussion

Usually, terrestrial mammal and reptile strikes account for approximately 3% of known reports around the world (Barras and Wright 2002, Dolbeer et al. 2005, Cleary et al. 2006, ATSB 2012, Crain et al. 2015). The number of collisions involving these animal groups in the MAO was much higher than those observed in other Brazilian airports. The city of Manaus is surrounded by the Amazon forest and includes >190 forest fragments varying in size of ≤700 ha (Novaes and Cintra 2013). This particular urban and forest matrix facilitates the presence

of wildlife. The total area of the airport comprises 1,400 ha, including 981 ha of forest fragments, which is a natural habitat for many species (Figure 1). This setting helps explain the high occurrences of wildlife strikes involving terrestrial mammals and reptiles at the MAO.

Most terrestrial species with strike reports in the MAO are known for their climbing abilities and therefore overcame the perimeter fence of the airport or crawled through small crevices. Such is the case for sloths, anteaters, opossums, and snakes. Small openings in the fence also allowed entry for animals such as alligators. The strike risk of terrestrial mammals and reptiles is becoming more evident, especially with the evolution of wildlife management programs in airports (DeVault et al. 2008, Crain et al. 2015). Dolbeer et al. (2005) gathered data from different countries on terrestrial wildlife strikes and noticed that even though the proportion of these strikes was usually small, 45% of strikes of this nature caused damage. Conversely, only 13% of bird or bat strikes caused damage.

An effective measure to diminish the risk of a wildlife strike is habitat management, which modifies the environment through the replacement of vegetation cover, removal of trees and shrubs, drainage or covering water ways and other methods (Barras and Seamans 2002). One proposed measure to isolate and control reptiles and mammals is to construct fences as physical barriers (DeVault et al. 2008, Biondi et al. 2011, VerCauteren et al. 2013). The MAO operation area is completely walled with a row of barbed wire 1.8 m high along the top of the fence. Nevertheless, fences should be improved so that small- and medium-sized species, such as those observed in aircraft strikes in the MAO, cannot climb, dig or gain entry. Studies suggest the use and daily monitoring of barriers, such as a chain-link fence 2 to 3 m high with a 1-m skirt and 3-strand barbed wire outriggers, or a fence 1.8 m high with horizontal mesh spacing <15 cm and with vertical spacing <10 cm with buried barbed wire to manage animals that can dig or climb (Green and Gipson 1994, Cleary and Dickey 2010, VerCauteren et al. 2013). For Xenarthra, fences should have a concrete underground protection and be curved at the top (135°). In the case of scansorial mammals, the utilization of electric fences has been proposed, but the method is currently too expensive for large-scale use (Honda et al. 2009).

The MAO has adopted some measures to avoid collisions between aircrafts and terrestrial mammals and reptiles. Routine fence checks identified flaws and possible entry points. Structural modifications included replacing iron bars with vertical mobile lids in drainage points on the bases of the fence. The MAO implemented maintenance of low grass height and removal of forest remnants close to the fence. However, further measures are needed, including an increase in fence height and adoption of concrete underground protection.

Aircraft–wildlife strikes present a global issue requiring both a local and global analytical perspective. Regional characteristics must be considered when planning airports and managing airport wildlife, especially in areas with high biodiversity. Studies and differentiated methods of wildlife strike management are important for each airport to understand fully and mitigate the risks imposed by the local fauna.

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Literature cited

Allan, J. R. 2002. The costs of bird strikes and bird strike prevention. Pages 147–153 *in* L. Clark, editor. Human conflicts with wildlife: economic considerations. Proceedings of the National Wildlife Research Center Special Symposium, Fort Collins, Colorado, USA.

ATSB. 2012. Australian aviation wildlife strike statistics: bird and animal strikes 2002 to 2011. Australian Transport Safety Bureau, Aviation Research Report AR-2012 31.

Barras, S. C., and T. W. Seamans. 2002. Habitat management approaches for reducing wildlife

use of airfields. Proceedings of the Vertebrate Pest Conference 20:309–315.

Barras, S., and S. E. Wright. 2002. Civil aircraft collisions with birds and other wildlife in Ohio, 1990–1999. Ohio Journal of Science 102:2–7.

Biondi, K. M., J. L. Belant, J. A. Martin, T. L. DeVault, and G. Wang. 2011. White-tailed deer incidents with U.S. civil aircraft. Wildlife Society Bulletin 35:303–309.

Cleary, E. C., and A. Dickey. 2010. Guidebook for addressing aircraft/wildlife hazards at general aviation airports. Transportation Research Board, Washington, D.C., USA.

Cleary, E. C., R. A. Dolbeer, and S. E. Wright. 2006. Wildlife strikes to civil aircraft in the United States 1990–2005. Federal Aviation Administration, National Wildlife Strike Database, Serial Report Number 12.

Cohn-Haft, M., A. Whittaker, and P. C. Stouffer. 1997. A new look at the "species-poor" central Amazon: the avifauna north of Manaus, Brazil. Ornithological Monographs 48:205–235.

Crain, A. R., J. L. Belant, and T. L. DeVault. 2015. Carnivore incidents with U.S. civil aircraft. Transportation Research Part D: Transport and Environment 36:160–166.

de Miranda, E. E., and C. Mattos. 1992. Brazilian rain forest colonization and biodiversity. Agriculture, Ecosystems and Environment 40:275–296.

De Oliveira, A. A., and D. C. Daly. 1999. Geographic distribution of tree species occurring in the region of Manaus, Brazil: implications for regional diversity and conservation. Biodiversity and Conservation 8:1245–1259.

DeVault, T. L., J. L. Belant, B. F. Blackwell, and T. W. Seamans. 2011. Interspecific variation in wildlife hazards to aircraft: implications for airport wildlife management. Wildlife Society Bulletin 35:394–402.

DeVault, T. L., B. F. Blackwell, and J. L. Belant, editors. 2013. Wildlife in airport environments: preventing animal–aircraft collisions through science-based management. Johns Hopkins University Press, Baltimore, Maryland, USA.

DeVault, T. L., J. E. Kubel, D. J. Glista, and O. E. Rhodes Jr. 2008. Mammalian hazards at small airports in Indiana: impact of perimeter fencing. Human–Wildlife Conflicts 2:240–247.

Dolbeer, R. A., S. E. Wright, and E. C. Cleary. 2000. Ranking the hazard level of wildlife species to aviation. Wildlife Society Bulletin 28:372–378.

Dolbeer, R. A., S. E. Wright, and P. E. Eschenfelder. 2005. Animal ambush at the airport: need to broaden ICAO standards for bird strikes to include terrestrial wildlife. Proceedings of the International Bird Strike Committee Meeting 27:102–113.

Green, J. S., and P. S. Gipson. 1994. Feral dogs. Pages 77–81 *in* S. E. Hygnstrom, R. M. Timm, and G. E. Larson, editors. Handbook: prevention and control of wildlife damage. University of Nebraska, Lincoln, Nebraska, USA.

Haugaasen, T., and C. A. Peres. 2005. Mammal assemblage structure in Amazonian flooded and unflooded forests. Journal of Tropical Ecology 21:133–145.

Honda, T., Y. Miyagawa, H. Ueda, and M. Inoue. 2009. Effectiveness of newly-designed electric fences in reducing crop damage by medium and large mammals. Mammal Study 34:13–17.

INFRAERO. 2015. Anuário Estatístico Operacional 2014. Empresa Brasileira de Infraestrutura Aeroportuária, Brasília, Distrito Federal, Brazil.

Martins, M., and M. E. Oliveira. 1993. The snakes of the genus *Atractus* Wagler (Reptilia: Squamata: Colubridae) from the Manaus region, central Amazonia, Brazil. Zoologische Mededelingen 67:21–40.

Novaes, W. G., and R. Cintra. 2013. Factors influencing the selection of communal roost sites by the black vulture *Coragyps atratus* (Aves: Cathartidae) in an urban area in Central Amazon. Zoologia (Curitiba) 30:607–614.

Ribeiro, A. 1991. Análise das variações climáticas observadas na região de Manaus (AM). Thesis, Escola Superior de Agricultura "Luiz de Queiroz," Universidade de São Paulo, Piracicaba, São Paulo, Brazil.

VerCauteren, K. C., M. Lavelle, and T. W. Seamans. 2013. Excluding mammals from airports. Pages 49–59 *in* T. L. DeVault, B. F. Blackwell, and J. L. Belant, editors. Wildlife in airport environments: preventing animal–aircraft collisions through science-based management. Johns Hopkins University Press, Baltimore, Maryland, USA.

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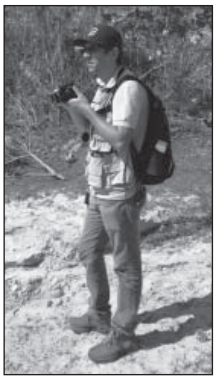

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