Interactions Between Wildlife and Civil Aircraft in Mississippi

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Abstract - Collisions between aircraft and wildlife have increased markedly since first recorded in 1905. These strikes threaten human safety and cost the United States civil aviation industry >$677 million annually. We examined the Federal Aviation Administration's national wildlife strike database records from 1990–2010 to characterize reported strikes with civil aircraft in Mississippi. We hypothesized that daily foraging patterns and seasonal differences would affect strike frequency for birds. We summarized 381 reported strikes (366 birds, 14 mammals, and 1 reptile) comprising ≥42 species. Bird strikes per 1000 aircraft operations (take-off and landing counted as separate operations) increased between 1990–2010. The monthly number of reported strikes per 1000 operations peaked July–September, coinciding with late breeding season and fall migration. Bird strikes per 1000 operations occurred more often during runway approach than during take-off, and more often at dusk than during other times of day. These patterns mirrored nationally observed wildlife-strike patterns. Our results may aid airport biologists in Mississippi to prioritize species management and more effectively implement timing and types of animal control efforts.

Introduction

Wildlife–aircraft collisions (hereafter, strikes) pose increasing safety and financial threats to civil aviation. These strikes result in an estimated annual worldwide cost exceeding $1.2 billion (Allan 2002, Blackwell et al. 2009a, Dolbeer and Wright 2008). Globally, strikes involving birds have caused 276 human deaths and destroyed 108 civil aircraft (Thorpe 2010). In the US, estimates suggest that strikes cost the civil aviation industry >$677 million dollars in 2010 (Dolbeer et al. 2012) and caused 24 human fatalities and 235 injuries from 1990–2010 (Dolbeer et al. 2012). The Federal Aviation Administration (FAA) anticipates a 3.5% annual increase in US civil aircraft traffic through 2025 and construction of additional runways (FAA 2008), suggesting a continued increase risk of wildlife strikes (Blackwell et al. 2009a).

Wildlife abundance and habitats beyond airport boundaries are an important consideration when managing strike risk (Dolbeer 2011, Martin et al. 2011), particularly within approach and departure zones of aircraft runways (Blackwell et al. 2009a, Dolbeer 2006). Despite management success in reducing wildlife strikes within boundaries (i.e., generally at altitudes <152 m [500 ft]; Dolbeer 2011), regional priorities for wildlife management at airports differ. For example, with

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increasing urbanization in the US, a variety of bird species, and mammals such as *Odocoileus virginianus* Zimmermann (White-tailed Deer) and *Canis latrans* Say (Coyote), have adapted to urban environments and use airport habitats (Dolbeer and Wright 2009). Blackwell et al. (2013) suggested that by integrating our understanding of species' seasonal use of resources for foraging and breeding with a knowledge of antipredator behaviors, managers can manipulate both resources and perceived risk to reduce wildlife use of airport habitats.

In Mississippi, airports are exposed to birds migrating along the Mississippi and Atlantic Flyways (Bellrose and Sieh 1960). Wildlife managers in the state are increasingly confronted with management of large bird and mammal populations that exploit agriculture and aquaculture resources, and pose a potential strike risk through their use of airport habitats. We sought to gain a better understanding of the species struck by aircraft at Mississippi airports relative to year-to-year dynamics, within-year dynamics, time of day, and phase of flight. We hypothesized that seasonal biological influences, such as bird migration, would affect the frequency of strikes due to the influx of individuals moving through Mississippi, much as collisions with wind turbines have seasonal influences in other geographic areas (Hüppop et al. 2006). We expected that the fall migration period would have the greatest strike rate because bird abundance increases after the breeding season (Dolbeer et al. 2012). We also hypothesized that daily foraging patterns would be an important factor in bird-aircraft interactions, and we predicted a greater frequency of strikes at dawn and dusk. We also predicted that most strikes would occur during the approach phase of flight because the aircraft is moving at a slower speed than at take-off (Dolbeer et al. 2012). Our objectives were to evaluate temporal and spatial patterns in wildlife strikes reported to the FAA for airports in Mississippi and develop management guidance relative to these findings.

Methods

We tested our hypotheses using records from the FAA national wildlife strike database for the state of Mississippi. The FAA national wildlife strike database consists of information that is voluntarily reported to the FAA by pilots and airports using FAA Form 5200-7 (Dolbeer et al. 2012). Data in these reports include the airport, wildlife species involved, size of the animal, time of day, severity of aircraft damage, month, year, and phase of flight. We queried the database for the years 1990–2010 using the keywords Mississippi and civil aircraft to obtain data for this study. Because not all reports were complete, sample sizes varied among comparisons.

We summarized the reported strikes using the FAA's air traffic activity system airport operation data from 1990–2010 for civil aircraft in Mississippi (FAA 2012). We identified the number of species or species groups involved in reported strikes from these reports. We also classified these groups in relation to hazard-level rank (DeVault et al. 2011, Dolbeer and Wright 2009). Because birds represented 96% of reported strikes, we evaluated only bird strikes in our analyses, but include descriptive statistics for other taxa (Table 1). We considered each take-off and landing as a separate operation and standardized the number of reported bird strikes per 1000 operations based on data from the air traffic activity system report (FAA 2012).

We then calculated the frequency of standardized strikes by phase of flight—taxi, take-off run, climb, approach, and landing. Take-off run and landing are when the aircraft altitude is at 0 m above ground level (AGL), climb is from 0 m AGL to cruising altitude, and approach will vary depending upon required rate of descent from altitude (US DOT FAA 2007).

Table 1. Number of reported wildlife strikes (*n* = 381) with US civil aircraft and associated hazard level by bird species, Mississippi, 1990–2010. Hazard level values were assigned by Dolbeer and Wright (2009).

Group	Strikes reported	Hazard level
Unknown small bird	111	
Unknown medium bird	62	
Zenaida macroura (L.) (Mourning Dove)	43	Moderate
Charadrius vociferous (L.) (Killdeer)	16	Low
Gulls	13	Very high
Swallows	13	Very low
Blackbirds	12	Low
Hawks	12	Moderate
Meadowlarks	10	Low
Sparrow	10	Low
Unknown large bird	10	
Geese	7	Extremely high
Odocoileus virginianus (Z.) (White-tailed Deer)	7	Extremely high
Vultures	6	Extremely high
Ducks	5	Extremely high
Canis latrans (S.) (Coyote)	5	High
Unknown bird	4	
Owls	3	High
Sturnus vulgaris (L.) (European Starling)	3	Moderate
Turdus migratorius (L.) (American Robin)	3	
Columba livia (G.) (Rock Pigeon)	2	High
Mimus polyglottos (L.) (Northern Mockingbird)	2	Low
Progne subis (L.) (Purple Martin)	2	Low
Ardea Herodias (L.) (Great Blue Heron)	2	Very high
Haliaeetus leucocephalus (L.) (Bald Eagle)	1	Extremely high
Corvus brachyrhynochos (B.) (American Crow)	1	High
Egret	1	High
Canis lupus familiaris (L.) (Domestic Dog)	1	Very high
Melegris gallopavo (L.) (Wild Turkey)	1	Very high
Falco sparverius (L.) (American Kestrel)	1	Very low
Chaetura pelagica (L.) (Chimney Swift)	1	Very low
Chordeiles minor (F.) (Common Nighthawk)	1	Very low
Scolopax minor (G.) (American Woodcock)	1	
Molothrus ater (B.) (Brown-headed Cowbird)	1	
Bos primigenius (B.) (Cattle)	1	
Sialia sialis (L.) (Eastern Bluebird)	1	
Eremophila alpestris (L.) (Horned Lark)	1	
Grus Canadensis (L.) (Sandhill Crane)	1	
Porzana carolina (L.) (Sora)	1	
Tern	1	
Turtle	1	
Gallinago delicata (O.) (Wilson's Snipe)	1	

We calculated the total number of reported strikes and the number of strikes by period of day, with dawn and dusk representing 0.75 hr and night and day 11.25 hr per diel period (after Biondi et al. 2011, Wright et al. 1998). Therefore, strikes were standardized by hours per diel period, but we could not standardize these values by number of operations because insufficient data were available in publicly accessible databases.

We used linear regression to compare the number of reported strikes (standardized by number of operations) by year and used piecewise regression to detect seasonal thresholds in strike rates. We compared models using Akaike's information criterion (AIC) (Burnham and Anderson 2002). We used goodness-of-fit tests to compare numbers of reported strikes by aircraft movement type and season with 95% confidence intervals. We also used goodness-of-fit tests to compare time of day, and then we applied the Marascuilo procedure to find significance between differences in proportions (Berenson et al. 2012). We used program R (R Development Core Team, 2011) with a priori statistical significance determined by $\alpha \leq 0.05$ for all analyses.

Results

There were 381 reported strikes with US civil aircraft in Mississippi from 1990–2010 (Table 1). Birds accounted for 96% of reported strikes (n = 366; Table 1) at 20 airports, with 81% at Jackson-Medgar Wiley Evers International Airport and Gulfport Biloxi Regional Airport (Fig. 1). Wildlife categorized at the moderate or greater hazard level (Dolbeer and Wright 2009) accounted for 62% of total reported strikes.

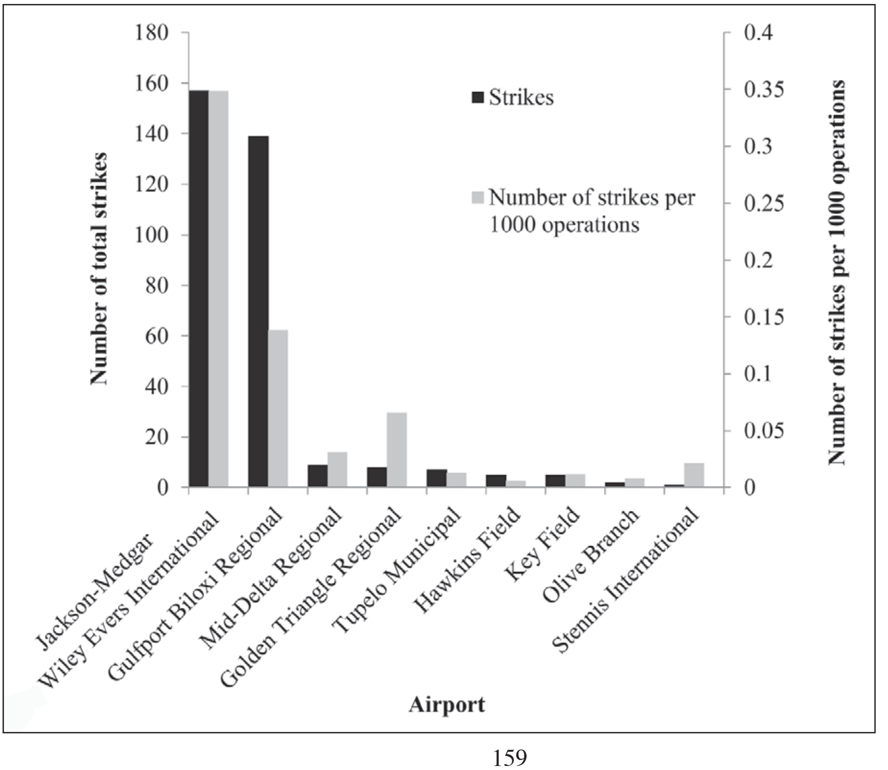

Figure 1. Number of reported bird strikes (n = 333) with US civil aircraft in Mississippi, 1990–2010.

The number of reported bird strikes per 1000 operations increased from 1990 to 2010, (r^2 = 0.77, P < 0.01, df = 18; Fig. 2). Within years, the number of reported bird strikes per 1000 operations has a distinct seasonal pattern showing no change in strikes from January to April (-0.006, ± 0.014), an increase from April to July (0.051, ± 0.017), and a decline from July to December (-0.066, ± 0.011) (r^2 = 0.87, P < 0.03, df = 6; Fig. 3). Reported strikes were more frequent during approach than during other operations (χ_4^2 = 120.53, P < 0.01; Fig. 4). The greatest number of reported strikes-per-hour occurred during dusk, followed by dawn, day, and night, respectively (χ_3^2 = 17.87, P < 0.01; Fig. 5); strike rate differed significantly between dusk and night.

Discussion

A recent 25% increase in strike reports across the US presumably has been in response to the 2009 Hudson River bird-strike incident in which an airliner carrying 155 people was ditched after hitting at least one bird (Dolbeer et al. 2012, Marra et al. 2009). Similarly, we found an increase in reported strikes since 2009 in Mississippi (Fig. 2). However, Dolbeer (2011) found that strike rates outside the airport environment (>152 m above ground level) increased in the years preceding 2009; thus, increased reporting does not entirely explain the increase in reported strikes. For 51% of the reported strikes in the FAA database, the birds involved were not identified to species (Dolbeer et al. 2012). The FAA encourages airport personnel to collect and send bird parts recovered from strikes to the

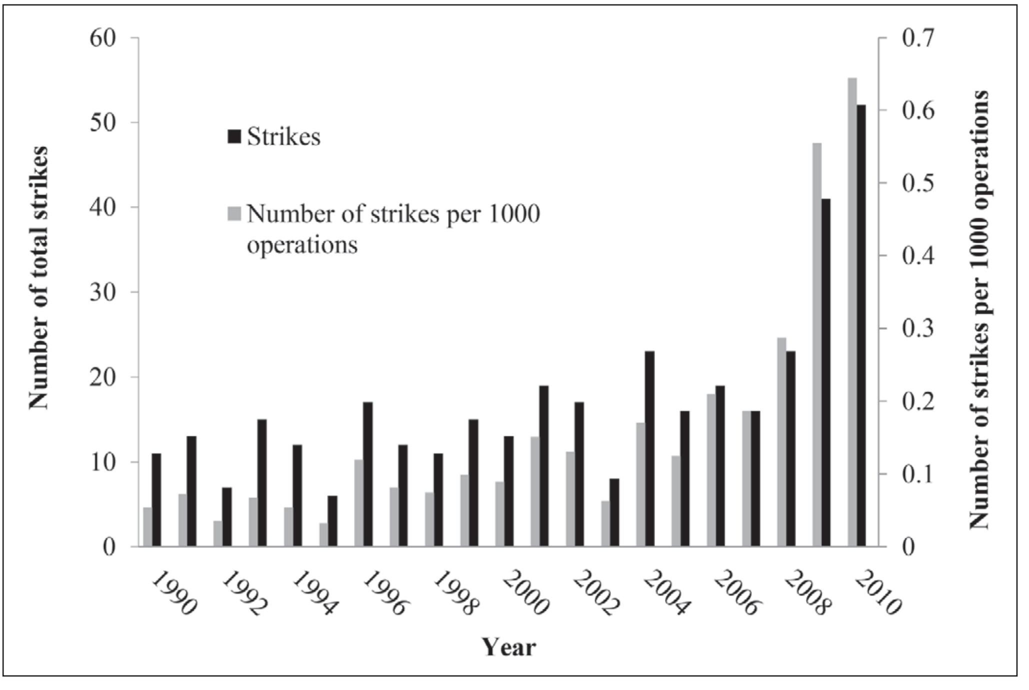

Figure 2. Number of reported bird strikes with US civil aircraft (n = 366) reported per year in Mississippi, 1990–2010.

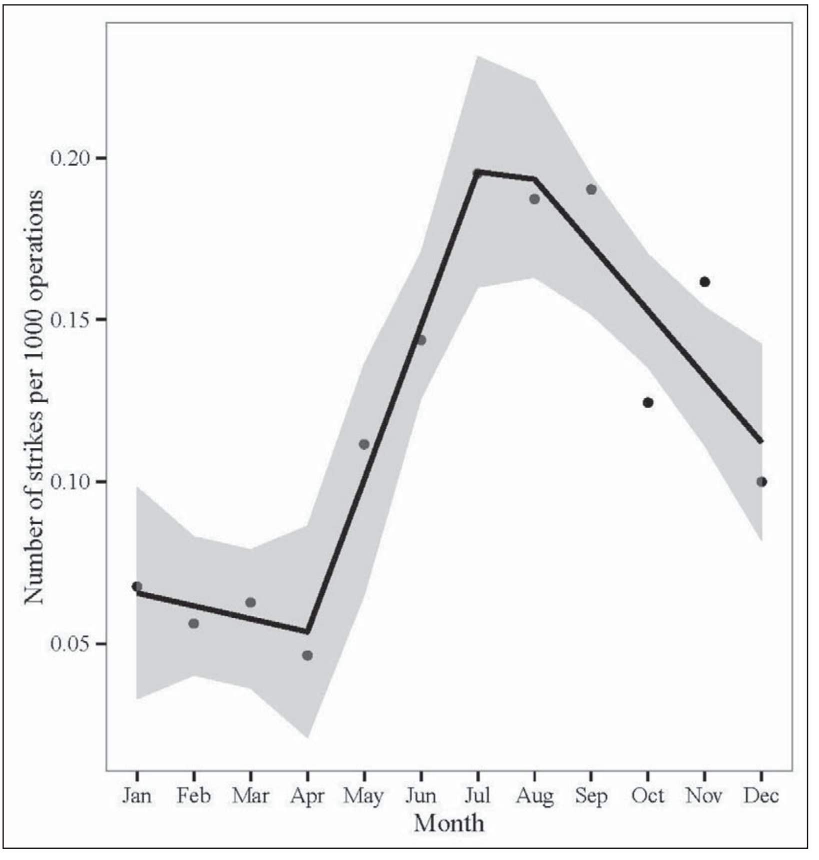

Figure 3. Rate of bird strikes (n = 366) with US civil aircraft by month (±95% CI) in Mississippi, 1990–2010. The piecewise regression is defined as $y = 0.06 + -0.004 * x * I(x < c_1) + 0.051 * x * I(c_2 > x > c_1) -0.066 * x * I(x > c_2)$, where x is the month, c_i is the breakpoint, and I is an indicator. Estimated breakpoints, c_1 and c_2, were 4.0 ± 0.68 (SE) and 7.3 ± 0.40 (SE), respectively.

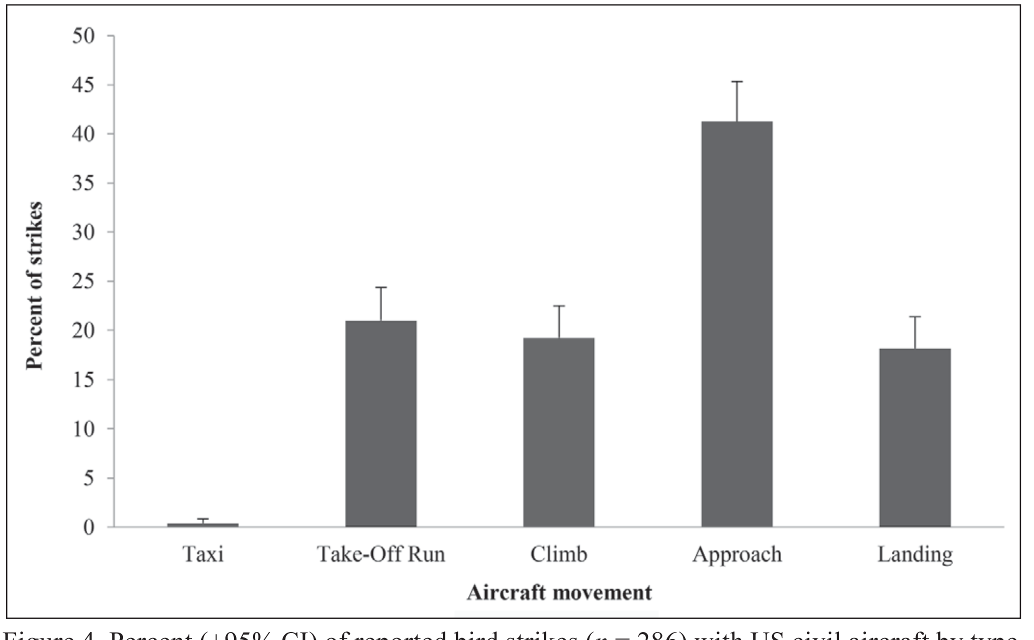

Figure 4. Percent (+95% CI) of reported bird strikes (n = 286) with US civil aircraft by type of aircraft movement in Mississippi, 1990–2010.

Smithsonian Institute in Washington, DC for identification to species (Dolbeer et al. 2012).

Mississippi airports with the most reported strikes were among the largest and busiest: Jackson Evers International (Jackson, MS), Gulfport Biloxi Regional (Biloxi, MS), and Golden Triangle Regional (Columbus, MS). All of these airports are located near urban environments and major water bodies. These environments harbor many of the species struck in Mississippi, including *Branta canadensis* (Canada Goose), *Charadrius vociferous* (Killdeer) and gulls. Mississippi is a mostly rural state with few population centers, and most strikes occur at airports near those centers. Future urban development around existing airports should consider the risk to aviation as a consequence of development (Blackwell et al. 2009a).

We predicted more bird strikes during spring and fall during bird migration. We found the number of strikes was steady from January to April, increased markedly

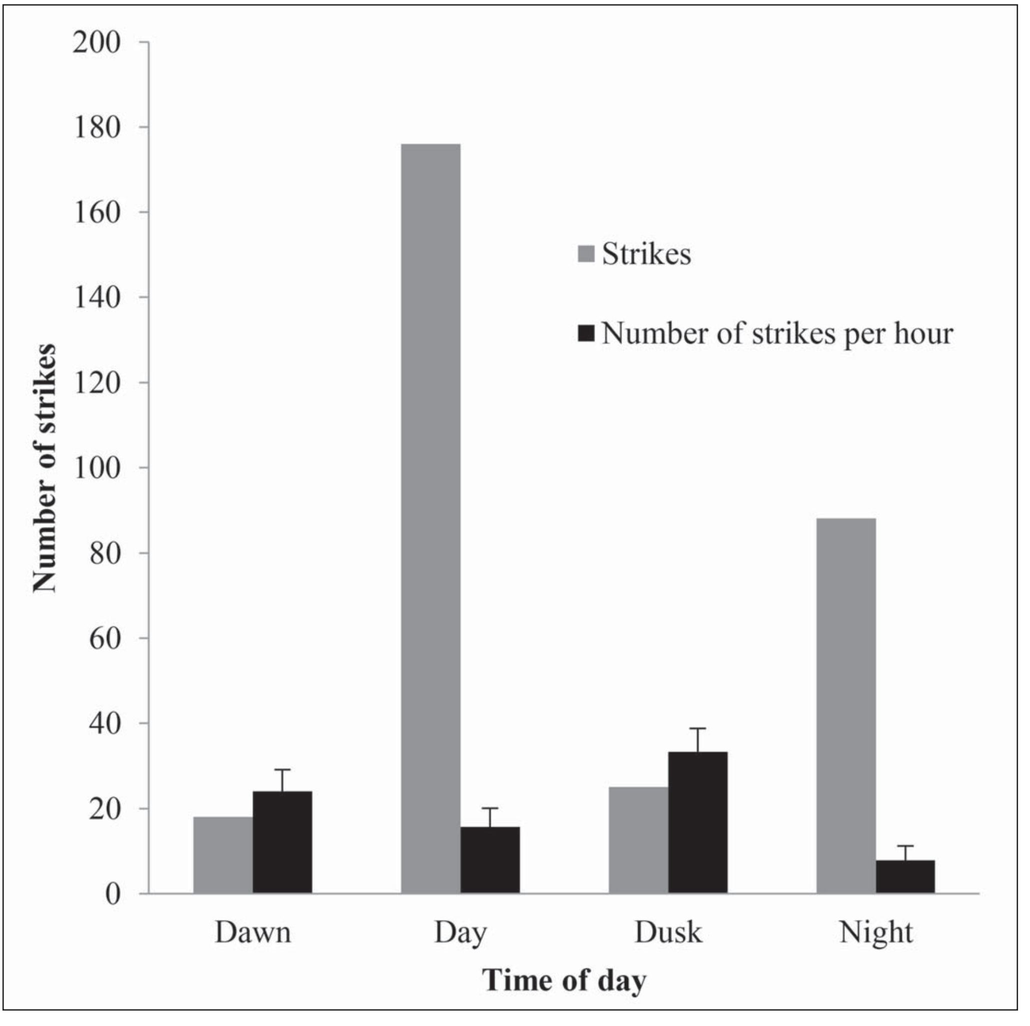

Figure 5. Number and rate (+95% CI) of bird strikes (n = 307) with US civil aircraft by time of day in Mississippi, 1990–2010, with statistical significance between dusk and night.

from April to July, then followed by a decline from July to December. The increase in April through July may be associated with increased movements to establish breeding territories and undertake courtship (Greenwood and Harvey 1982), as well as the influx of inexperienced juveniles that may be more likely to collide with aircraft (Arnett et al. 2008).

Analysis of the FAA data supported our predictions regarding diel patterns of bird strikes. We based our initial predictions on bird biology—foraging mostly occurs in morning and evening making an interaction with aircraft more likely during those times (Bednekoff and Houston 1994, Coleman and Richmond 2007). Our results show that most strikes occurred during dusk. This finding highlights the possibility that food acquisition and movements to roost sites are the primary reasons that birds use the airport environment, as has been suggested by others (Blackwell et al. 2013, DeVault and Washburn 2013). Birds may also be impaired by reduced visibility in low-light conditions, reducing the birds' ability to make effective behavioral responses to aircraft. Birds are known to respond to aircraft by attempting to avoid being struck (Bernhardt et al. 2010), but we know of no studies that explain how environmental conditions affect response times.

Our results support our prediction that most strikes occurred during the approach phase. Dolbeer (2006) showed that 74% of all strikes occur at <152 m (<500 ft) AGL. We hypothesize that birds' response to aircraft varies with aircraft flight-phase because of differences in flight speeds, angle of the aircraft, and noise levels (Bernhardt et al. 2010, Blackwell et al. 2009b). We believe that current work on birds' response to aircraft lighting and color-scheme design will help to improve understanding of bird avoidance-behavior (e.g., Blackwell et al. 2012).

Because the FAA anticipates a 3.5% increase in US civil aircraft traffic through 2025 (FAA 2008), we encourage additional management efforts to reduce bird strikes (see Dolbeer et al. 2012), with emphasis on time periods of greatest bird movement and use of the airport environment such as migration and twilight hours. Research and monitoring of the airport environment will elucidate the mechanisms driving patterns of bird movement and will inform risk-mitigation strategies. We recommend that managers identify struck birds to species to fine-tune management approaches. Fortunately, none of these strikes has caused major property loss or major human injury in Mississippi; however, wildlife–aircraft strikes are inevitable and through proper reporting, bird monitoring, continued research in deterring birds, and implementation of management recommendations, we can decrease strike risk.

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