

Sex and Age Bias in Australian Magpies Struck by Aircraft

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Simple Summary: Assessments of wildlife collision probability with aircraft are generally based on species-by-species assessments, yet collision probability may not be equally distributed demographically within species. We show that adult female Australian Magpies are struck by aircraft more frequently than adult males are than would be expected from observed sex ratios among adult birds recorded during counts of magpies at a major Australian airport. Young magpies are also struck by aircraft more frequently than expected from their representation in the local population. The latter insight indicates that deterring magpie breeding in the immediate vicinity of an airport may reduce collision rates. Targeting juvenile magpies for harassment and dispersal at airports might be another useful management tactic.

Abstract: Wildlife–aircraft collisions represent a safety and financial challenge, necessitating site-specific hazard assessments, which are generally based on species’ attributes and collision frequencies. However, for many bird species, collision probability and risk may not be distributed equally among individuals, with sex and age differences possible but rarely examined. We examine Australian Magpies, a resident, grassland species of bird in southeastern Australia frequently involved in collisions with aircraft at airports, and which can be sexed (adults) and aged. We compared collision rates recorded at Melbourne Airport, Victoria, Australia, with airside counts of magpies, recording, when observable, the sex and age of the birds. Adult females and males were similarly abundant at the airport (46.6% female), but females were struck relatively more frequently than males (78.1% female). Juvenile (first-year) magpies were struck more frequently than expected based on their representation in bird counts. We show an example of where some demographic groups within species represent higher hazard potential to aircraft than others, and management which manipulates demography of magpies at and near the airport (such as discouraging local breeding and targeted harassment/dispersal) may be fruitful.

Keywords: bird strike; airport; bird hazard; hazard assessment; risk; wildlife



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1. Introduction

Vehicle– or aircraft–wildlife collisions risk human (and wildlife) safety and cost millions of dollars each year in damage and delays [1–7]. In particular, birds represent a prominent collision hazard to aircraft. Collisions between birds and aircraft have caused human fatalities and remain a key challenge in transport ecology [1,3,7]. Most collisions between aircraft and birds occur at airports, and risk assessments are usually airport- and species-specific, with some species thought to be more prone to collisions, because of abundance, movements such as migration, foraging, or defensive behavior, amenability to management, and capacity to learn [6–8]. Larger-bodied species of bird are generally considered more frequently identifiable following collisions with aircraft and represent a greater hazard by causing aircraft damage (although flocks of smaller birds can also cause issues [6]). The traits that mediate collision probability are generally considered to be environmental, such as weather conditions, or species-specific. While this is undoubtedly

the case [6–8] there may be within-species variation. Not only might the time of year affect strike probability (e.g., migration [7,9–12] or nesting [13,14]) but demographic classes might present different risk profiles; most notably between individuals of different age and sex.

Sex may mediate collision probability and risk. Some birds exhibit sex-specific habitat-use [15], movement such as dispersal [16–18], and diurnal activity budgets [19]. Some birds exhibit sex role specializations such as parental care and defense [19], as well as risk-taking in general [20]. Thus, sex may mediate collision probability. For example, Canada Geese (*Branta canadensis*) movements in areas in which collisions with aircraft might occur vary with sex and season [21]. Eurasian Skylarks (*Alauda arvensis*) struck by aircraft on an Irish airfield were 83% male, presumably because males engage in aerial displays [22]. A statistically significant sex bias (64% male) in Laughing Gulls (*Larus atricilla*) struck by aircraft at one North American airport has been reported [23]. However, no other accounts known to us examine the sex or age of birds struck by aircraft, an information gap identified at least 20 years ago [24]. Furthermore, the reported sex biases do not account for prevailing sex ratios at airports, meaning that collision probability may not actually vary between the sexes, but rather simply be the result of the underlying sex ratio at the airport.

Age may also mediate collision probability. Young animals may have limited experience in avoiding collisions, relatively poor locomotory skills during collision avoidance, lower capacity to identify threats, shorter detection distances, or have more precarious energy balances leading to greater risk-taking [25–29]. Many young birds disperse, meaning they can occur in unfamiliar environments [30], and survival of young birds is typically lower than that of adults [17,26]. Consequently, in some cases, young birds may be expected to be more collision-prone than adults of the same species [27], although it must be noted that some studies show no age-related bias in collision probability [31,32].

One species in which the sex and age of aircraft-struck birds can be examined is the Australian Magpie (*Gymnorhina tibicen*). This species is a resident ground-foraging passerine common in open grasslands of Australia, where it also inhabits airfields [33,34]. It can habituate to some extent to nearby aircraft and is frequently struck by aircraft on airfields, where it is considered a bird hazard [35]. Its body mass is relatively high compared to most other birds frequently struck by aircraft in southern Australia (in Victoria, mean of 305.8 g, range 238–385 g [33]), meaning that collisions can, and do, cause damage [36]. Furthermore, the species is social, occurring in groups, and multiple birds can strike a single aircraft, contributing to damage [6,8].

Magpies can be aged and adults can be sexed by bare-part coloration and plumage [33]. Casual observation suggested that juvenile magpies at Melbourne Airport were involved in more collisions with aircraft than might be expected from their presumed representation in local populations. The species' size means that when birds are struck by aircraft, magpies are usually identifiable from remains (whereas many smaller species cannot be readily identified after a high-speed collision), and some magpie remains can be aged and sexed. Thus, the species presents an opportunity to examine possible demographic differences in collision probability.

In general, adult birds do not always occur in equal sex ratios, with some species and areas exhibiting biases in the number of one or the other sex [37]. Such biases might explain sex biases among birds involved in collisions with aircraft, wind turbines, or road vehicles, when reported. This means comparing sex-related bias in collisions must be compared to any sex ratio in local populations if meaningful conclusions are to be made.

Understanding whether particular demographic classes of birds are more likely to collide with aircraft could inform tailored management approaches focused on reducing those ages/sexes representing the greatest probability. Additionally, where sexual dimorphism in body mass occurs, different sexes may impart different levels of damage to aircraft when struck. The same may be true for young birds which, in the case of Australian Magpies, may be lighter than adults after they leave the nest [33] and then are theoretically exposed to collisions with aircraft. We examine the demographic patterns of aircraft–magpie collisions at a major airport and make two predictions. First, we predict that first-year magpies

will represent a higher collision probability compared with their representation in local populations. Since the annual survival probability of young birds is often lower than that of adults [34], and young birds mature quickly relative to their lifespan, young birds can be expected to represent a relatively low proportion of local populations. Second, we predict that the sexes should not differ in terms of collision probability, in a species in which mature pairs use similar habitats and space, sharing parental care and defense of young.

2. Materials and Methods

Melbourne Airport (37°40'24" S, 144°50'36" E) is a major international airport servicing the city of Melbourne (c. 5 million residents) in Victoria, Australia. It was selected because rigorous records of aircraft collisions with magpies, and associated bird counts, were available. The airport is Australia's second largest in terms of aircraft and passenger movements; for context, some 37 million passengers used the airport during 2018 [38]. During 2018, the airport saw a total of 245,766 air traffic movements, including 244,900 movements by aircraft of 7–136 tonnes [39]. The airport operates two runways: a north–south runway (16/34), which is 3657 m long and 60 m wide, and an east–west runway (09/27), which is 2286 m in length and 45 m wide, with an airside maneuvering area of some 750 ha. Overall, Melbourne Airport manages 2740 ha of property [39].

As part of Melbourne Airport's wildlife hazards management program, standardized bird counts of the airside were conducted by WKS between July 2000 and June 2020 on a regular basis (at least monthly). Security and safety considerations restrict observer access to the airport's perimeter road and other tracks but allow visual access to the entire airside and 50 m, or more, outside the perimeter fence (see [40,41] for a general account of grid-based surveys on airports and [42] for a map of grids used). Bird counts were undertaken by car, following a fixed route (~18.5 km) at slow speed (~20 km/h), with stops of 3–10 min at selected vantage points to exit the car and scan surrounding areas through binoculars, and to listen for bird calls after [40]. Counts were standardized to commence at 08 h30 and be completed within 3 h. All birds (and other wildlife) seen were identified and enumerated, then recorded by time and location first seen (using an imaginary 200 m × 200 m grid across the airside [42]). Although it was impossible to entirely exclude any possibility of double-counting some birds, or overlooking others, great care was taken to watch for bird movements [40,41]. With the open nature of the airside enabling extensive views, we believe the amount of any double-counting would be trivial. During the counts, Australian Magpies were aged and sexed by bare-part and plumage characteristics only when good views of diagnostic features allowed. Not all birds were identified by age class or sex because diagnostic features were not always visible given the range of sighting, animal movements, rain, etc. But, when it could be determined with certainty, magpies were classified as adult male, adult female, subadult, or juvenile (first-year). Although bird counts of Melbourne Airport's airside extend beyond the 12 October 2000–27 December 2016 period for which we have assessed magpie remains, we considered only those counts concurrent with this period to provide the best possible temporal comparability. While the bird counts do not perfectly overlap the sampling period from struck magpies, we assume they are representative of the sedentary and stable population of magpies.

All suspected wildlife collisions must be reported by air crews [1,2]. At Melbourne Airport, all reported strikes are immediately followed by ground staff searching for animal remains. In addition, regular runway inspections and flight strip patrols actively search for, and recover, animal remains throughout each day. Animal remains were collected by airport staff in plastic bags, labelled, and stored in a freezer until they could be examined by an ornithologist. Magpie remains were usually distinctive given the species' size and plumage coloration. Sex/age categories were assigned when magpie remains were sufficient for such assessments. In the case of unrecognizable remains, or blood smears on aircraft, DNA testing was carried out to identify the species involved. In all such cases during our study (i.e., where blood smears were the only evidence of a collision), even when the

Australian Magpie was identified as the species involved, the age/sex of individuals was not ascertained.

We compare the proportion of adult male and adult female magpies observed in the local population over the period when magpie carcasses were collected following collisions, with the proportion of each category identified in aircraft collision casualties. We also compare the relative proportion of first-year magpies in the local population with the relative proportion of first-year birds among magpies involved in collisions with aircraft.

Adult magpies can be sexed, either in the field during counts or from inspection of remains, on the basis of plumage characteristics; in southern Victoria, adult males have distinctly ‘clean’ white napes and mantles whereas adult females have grayish feathers in these areas. Young birds can often only be identified as such from bare-part coloration and/or specific plumages, which often (but not always) last no more than a few years post-hatching. In the Australian Magpie, juvenile (first-year) birds can be distinguished when handled and when in the field, but young birds cannot be sexed. Subadult (non-breeding) birds can be distinguished from breeding adults by bill size and color [33]; however, some ambiguity can occur when identifying subadults at distance, so we do not analyze these.

All data represent frequency analysis and are analyzed with contingency analysis using Yate’s correction for continuity (because $df = 1$) [43]. The expected values are based on population counts at the airport and do not assume an equal sex or age ratio.

3. Results

At Melbourne Airport, we have records of 248 aircraft collisions with Australian Magpies between 1986 and 2020; 68 of these incidents have the age/sex of the bird recorded [44]. Adult female magpies were involved in 37.9% of collisions, and first-year birds in 40.9% (Table 1). These proportions are greater than expected from their proportions in the local population (see below).

Table 1. Australian Magpies involved in aircraft collisions at Melbourne Airport, where age/sex could be determined.

Age/Sex Category	Number	Percentage
Adult (unsexed)	2	2.9
Adult male	7	10.3
Adult female	25	36.8
Subadult	7	10.3
First-year	27	39.7
Total	68	100.0

All incidents with age/sex of magpie recorded occurred between 12 October 2000 and 27 December 2016. Over this period, there were 1182 confirmed wildlife-strikes at Melbourne Airport; 140 (11.8%) involving magpies [44]. Thus, magpies present a substantial risk to aircraft operating from this airport.

Between 12 October 2000 and 27 December 2016, we conducted 225 counts of birds across the airside of Melbourne Airport. During these 225 counts, we observed 12,055 magpies, with an average of 53.6 ± 27.0 magpies per count. A total of 11,414 of the magpies counted (94.7%) did not have their age/sex recorded. Of those birds assigned an age/sex category, adults were not heavily skewed towards one sex, with numbers counted broadly similar between adult males ($n = 198$, 30.9% of categorized birds) and adult females ($n = 173$; 27.0% of all categorized magpies including young) (Table 2).

First-year birds made up a substantial proportion of the magpies counted on the airside (26.8% of magpies assigned an age/sex category) (Table 2). Our counts, which included groups of magpies, suggest that the airside was attractive to unpaired and non-territory-holding magpies and, especially, first-year birds—presumably after their dispersal from natal territories see [34].

Table 2. Age/sex of Australian Magpies observed across Melbourne Airport between 12 October 2000 and 27 December 2016 ($n = 225$ counts).

Age/Sex	Number	Percentage of Categorized Magpies
Adult (unsexed)	36	5.6
Adult male	198	30.9
Adult female	173	27.0
Subadult	62	9.7
First-year	172	26.8
Not recorded	11,414	
Total	12,055	100.0

3.1. Sex

Of 32 sexed adults that struck aircraft, 78% were female. Of 371 counted and sexed adult magpies at the airport, 46.6% were adult female and there was no sex bias in the adult population at the airport ($n = 371$; $\chi^2 = 1.55$, $df = 1$, $p = 0.787$). Contingency analysis revealed that the proportion of adult females struck by aircraft (adjusting expected values to the exact ratio of adult females to adult males recorded at the airport) was higher than that expected from the proportion of adult females at the airport ($\chi^2 = 11.52$, $df = 1$, $p < 0.001$).

3.2. Age

Of 61 aged magpies that struck aircraft, 44% were first-year birds. Of 579 counted and aged magpies at the airport, 30% were first-year birds (we exclude subadults from analysis due to a number of ambiguous designations). Contingency analysis revealed that the proportion of first-year birds struck by aircraft was higher than that expected from their proportion at the airport ($\chi^2 = 5.51$, $df = 1$, $p = 0.011$).

4. Discussion

We report the results of a small but medium-term study, conducted at only one (albeit major and busy) Australian airport. Female and young magpies were over-represented in collision frequencies with aircraft compared to their representation in the magpie population at the airport. This reinforces the idea that not all members of a population of a given species are at equal likelihood of being involved in collisions [27], as is often assumed in species-based risk assessments of wildlife–aircraft collisions. In terms of damage to aircraft, body mass does not appear to vary consistently between the sexes of Australian Magpies [33], and so the potential to damage aircraft would likely be similar between sexes.

Adult magpies at the airport occurred in a roughly equal sex ratios. The sex bias in aircraft collisions that we report is intriguing, especially given that adult magpies often forage together in open grassy areas. Across birds in general, females tend to be the dispersing sex while males exhibit philopatry more commonly, and it has been suggested that this explains lower female survival [17,18]. However, magpies are generally regarded as sedentary and in long-term pair bonds or non-territory holding groups that remain within a limited area, and adult-phase dispersal is limited [33,34]. Energetic demands on females when breeding may alter risk-taking when foraging [45] and warrants further investigation. While few accounts of sex bias in birds struck by aircraft are available, it can evidently be either sex which is struck more frequently ([22], this study). In the case of Eurasian Skylark males being struck more frequently than females, differences in behavior are stark (males conduct aerial display flights); any differences in the case of sex-related magpie behavior are less evident or may not exist.

The bias towards young magpies being struck more frequently is less surprising and accords with young birds being at higher collision probability with a variety of vehicles and human structures [27]. Young magpies are known to be more risk-prone than adult birds and more vulnerable to threats [34]. However, being slightly lighter than adults [33], they may be less likely to cause aircraft damage during collisions. Suppressing local breeding of

magpies would decrease the number of juvenile birds found on the airside, and potentially decrease the number of magpie aircraft collisions. However, the number of territories at Melbourne Airport held by magpie breeding pairs is already limited due to the planned dearth of tall trees suitable for nesting and likely does not exceed eight territories (Pers. Obs.). Our observations suggest that many magpies occurring at Melbourne Airport are non-territory-holding groups, referred to as 'Marginal Groups', 'Mobile Groups', or 'Open Groups' [33], which move onto the airside because of the extensive grassland foraging habitat it provides and, despite the dangers posed by aircraft, a relatively safe area, largely free of humans, road traffic, and predators.

Melbourne Airport authorities have emphasized the utility of focusing on juvenile birds when magpie harassment and dispersal is required, and especially when culling is needed to provide lethal reinforcement to dispersal efforts. There is some suggestion this focus on juvenile magpies has been effective in reducing the strike frequency for magpies at Melbourne Airport (Unpubl. Data), although more data and analysis are required before there can be any certainty on this point.

5. Conclusions

Wildlife at airports present a hazard for aircraft operations, particularly through the possibility of high-speed collisions with flying birds. Understanding the factors influencing collision-probability for different species has been central to development of hazard-reduction strategies at many airports. However, we show that the hazard presented by at least one species of bird (the Australian Magpie) varies depending on demographic group, adult females and juvenile (first-year) birds being involved in a greater proportion of aircraft collisions involving that species than their proportion in one airport population (although first-year birds are lighter than adults). Clear explanations of the underlying mechanisms which resulted in the biases we report are not currently available. However, further research on patterns of likelihood of collision across demographic categories appear warranted across broader geographical and taxonomic scopes.

Depending on the goals of a given airport's Wildlife Hazard Management Plan (e.g., reduce the number of bird strikes versus reducing the number of damaging strikes), strategies prioritizing these particular demographic groups for targeted management might be effective in reducing the hazard through efficient use of the often-limited wildlife management resources available to airports. We conclude that improved demographic resolution in hazard assessments may prove useful for other species of wildlife likely to exhibit within-species variation in collision probability.

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