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Factors affecting pilot-reported bird-strike rates at Christchurch International Airport, New Zealand

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Abstract Pilots' reports of their aircraft striking birds or having near misses at Christchurch International Airport from 1981 to 1993 were analysed to identify factors influencing the rate of such incidents. A preliminary analysis indicated that reporting of near misses was not influenced by recent bird strike incidents, which suggested that the data were reasonably robust to variation in pilot awareness of the problem. A total of 362 strikes was reported during the survey period, most commonly involving sparrows and gulls. Pilots were more likely to report near misses if the birds were large (e.g., gulls *Larus* spp., spur-winged plover *Vanellus miles novaehollandiae*, white-backed magpies *Gymnorhina* spp., and Australasian harrier *Circus approximans*) than if they were small (e.g., sparrows *Passer domesticus* and finches *Carduelis* spp.). The risk of an aircraft being struck varied both diurnally and seasonally, being highest at 0800–1000 h and in April. Birds seemed better able to avoid Boeing 737s than the quieter Boeing 767s and Whisper Jets. Bird-strike rates increased progressively in the early and mid 1980s, but this increase appears to have been halted through an intensive bird management programme in place since 1987 and restrictions on agricultural activity and urban refuse near the airport. However, quarterly bird-strike rates have been significantly more variable since 1987; the reason for this is unclear. A preliminary cost/benefit analysis of this management programme is presented.

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INTRODUCTION

Bird strike of aircraft is a major concern for airport managers worldwide. Such incidents cost millions of dollars in damage to aircraft every year (e.g., Dolbeer et al. 1993) and increase the risk of aircraft crashing, with consequent passenger injury or death (Blokpoel 1976).

Bird strikes are a problem at most New Zealand airports (Davidson & Rowell 1990), and Christchurch International Airport (CIA) has the highest recorded strike rate nationally (Department of Civil Aviation 1991). The problem at CIA has arisen from its close proximity to the Waimakariri braided river system, agricultural and horticultural land, two golf courses and, until 1987, an urban refuse dump. This combination of habitats attracts various species of birds into the take-off and landing flight paths of both domestic and international aircraft using CIA (Creswell 1988).

A serious bird-strike incident in 1985 led CIA managers to institute a more active bird management programme consisting of bird abundance and behaviour studies, habitat management, and various bird deterrent measures (H. McCarroll pers. comm.). A primary means of evaluating the success of this management has been a pilot-report scheme whereby CIA requires all pilots to complete a report on any bird strike or near miss.

In this study we analysed these pilot-report data to investigate factors influencing reported bird-strike rates; these included diurnal and seasonal effects, bird species, aircraft type, and the effect of intensified bird management begun in 1987.

METHODS

CIA runways and the surrounding area (43°29'S, 172°32'E) were inspected briefly in June 1993. We then analysed bird incident reports from CIA File 1162 (Bird Control); these contained the date and time of each incident, the type of aircraft involved, whether the incident was a "strike" or a "near miss", and the species and number of birds involved (where known).

It is well known that pilots under-report bird strikes (Hone 1994). A potential bias in such bird-incident data is that pilots may be more aware of the problem, and CIA's reporting requirements, in the period immediately after publicised incidents, so that their reporting rate increases temporarily (G. Pullyn pers. comm.; H. McCarroll pers. comm.). This was investigated by estimating the mean number of near-miss reports per day, corrected for mean number of aircraft movements per day, for the 28 days following each reported strike, and testing for any trend over time using linear regression.

The diurnal pattern of bird strike was assessed by pooling reports filed since management was intensified (1987–93) and calculating the relative strike rate corrected for the number of scheduled aircraft movements (estimated from airlines' flight timetables) at hourly intervals. Changes in the strike rate were tested using polynomial regression, weighted by the numbers of scheduled flights each hour. Seasonal patterns were assessed by calculating the mean number of strikes each month; between-month differences in the number of flights were assumed to be minimal. Differences in means between months were tested by one-way ANOVA. The effect of aircraft type and bird species on strike:miss ratios was tested using χ^2 tests of association or, when samples sizes were low, Fisher Exact tests.

The effect of intensified bird management in the late 1980s was evaluated using bird-strike counts recorded quarterly for the period 1981–93. Trends over time were tested using a general linear model (procedure MGLM in SYSTAT, with YEAR as a continuous variable and QUARTER as a categorical factor). The cost/benefit of intensified management was assessed by extrapolating the trend in bird strikes apparent before the management change through the period 1987–93, and then comparing these predicted numbers with the strikes actually reported in this period. Bird management costs were then compared with the estimated savings from the reduction in bird-strike repairs required by aircraft using CIA.

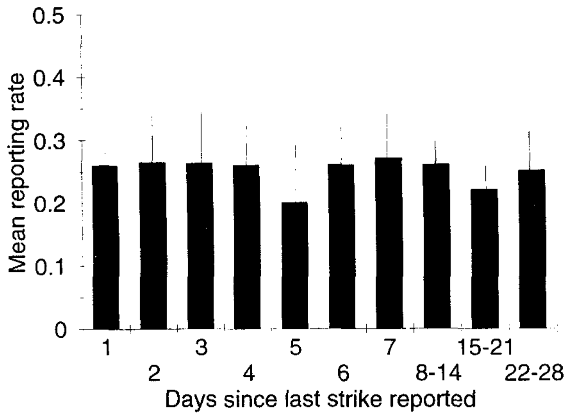

Fig. 1 Mean daily rate of pilot-reported near misses ± SE, in relation to the number of days elapsed since the most recent bird-strike report at Christchurch International Airport.

RESULTS

The number of near misses reported daily was not significantly influenced by how recently a bird strike had been reported (Fig. 1), which suggests that the reporting rate is reasonably robust to changes in pilot awareness of the problem. Nevertheless, we acknowledge that changes in incident reporting rate could be a factor in the results presented below.

Over the past 13 years (January 1981 to August 1993) 362 bird strikes have been reported at CIA. House sparrows (*Passer domesticus*) and gulls (*Larus* spp.) were the species most commonly identified in the strikes (Table 1). Large birds such as spur-winged plovers (*Vanellus miles novaehollandiae*), white-backed magpies (*Gymnorhina* spp.), and Australasian harriers (*Circus approximans*) also struck aircraft. These large species are relatively easy to identify and so are probably over-represented in Table 1 relative to smaller birds, which tended to be labelled as "finches" or "not identified". Similarly, the ratio of strikes to near misses was much higher for the small birds (e.g., sparrows and finches 1.73:1) than for the larger birds (gulls, spur-winged plovers, hawks, and magpies 0.22:1, $P < 0.001$), presumably because near misses of small birds are either less detectable or are considered less worthy of reporting.

Most strikes (91%) occurred between 0700 and 2200 h, when aircraft movements were most frequent. The number of strikes per hour in this period was positively correlated with the number of

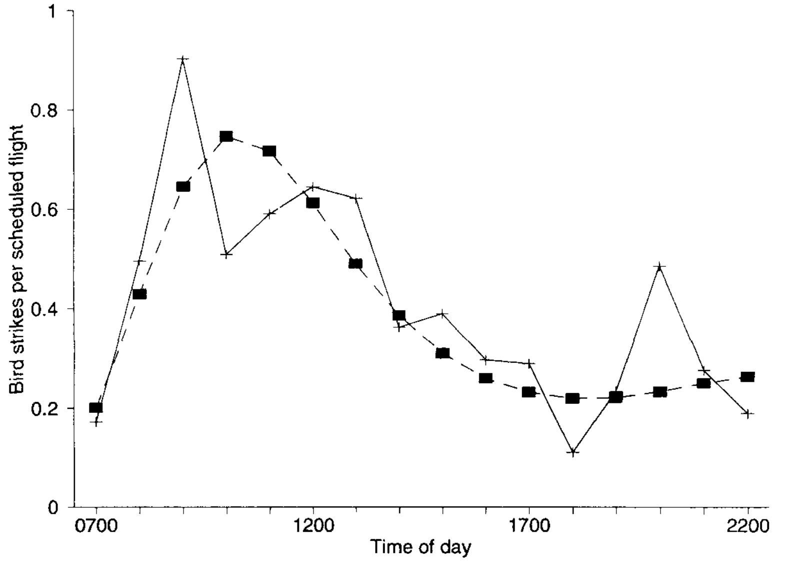

Fig. 2 Diurnal variation in bird-strike rates at Christchurch International Airport, corrected for variation in aircraft traffic rates. Pooled data from 1987 to 1993. The trend line (■ – ■) was fitted using weighted polynomial regression ($R^2 = 0.71$, $P = 0.003$).

scheduled flights per hour ($r = 0.54$, $P < 0.05$). When the data were corrected for hourly differences in aircraft traffic (by calculating strikes per scheduled flight), marked diurnal variation in strike rate was apparent (Fig. 2).

Diurnal variation was also evident in the number of strikes of the two most commonly reported species (sparrows $R^2 = 0.59$, $P < 0.001$; gulls $R^2 = 0.32$, $P < 0.02$). Sparrow strikes had a pronounced peak at c. 0800 h, whereas gull strikes were more widely spread and tended to peak in the middle of the day.

There was significant monthly variation in the number of strikes (Fig. 3; $F = 4.3$, $P < 0.001$), with a disproportionate number of strikes (26%) occurring in April. Compared with the rest of the year, April had higher than expected strike rates of sparrows (1.8 times as many; $P < 0.05$), finches (8.5 times as many; $P < 0.02$), and perhaps hawks (2.8 times as many; n.s.).

From August 1989 to August 1993 the three aircraft types for which strikes and near misses were most commonly reported were Boeing 737s (44 and

Table 1 Strikes, near misses, and strike:miss ratios for common bird species at Christchurch International Airport, August 1989 to August 1993.

Bird species		Strikes	Near misses	Strike: miss ratio
House sparrow	*Passer domesticus*	34	22	1.6
Unknown		18	33	0.6
Gull	*Larus* spp.	13	75	0.2
Spur-winged plover	*Vanellus miles novaehollandiae*	8	8	1.0
Finch	*Carduelis* spp.	4	0	4.0
Starling	*Sturnus vulgaris*	3	10	0.3
Australasian harrier	*Circus approximans*	2	14	0.1
White-backed magpie	*Gymnorhina* spp.	2	11	0.2
Australian rock pigeon	*Columbia livia*	2	10	0.2
Skylark	*Alauda arvensis*	2	3	0.7
Oystercatcher	*Haematopus* spp.	2	2	1.0
Blackbird	*Turdus merula*	1	4	0.3
Other	(six known species)	1	5	0.2
Mallard duck	*Anas platyrynchos*	0	5	0.0
Total		92	202	0.4

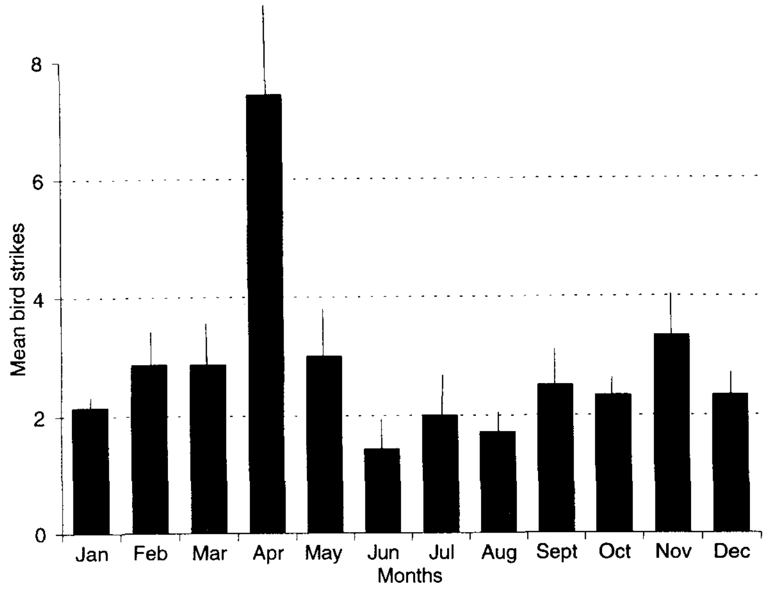

Fig. 3 Monthly variation in mean numbers of bird strikes ± SE, at Christchurch International Airport. Pooled data from 1987 to 1993 not corrected for variation in aircraft traffic rates between months, which was assumed to be minor.

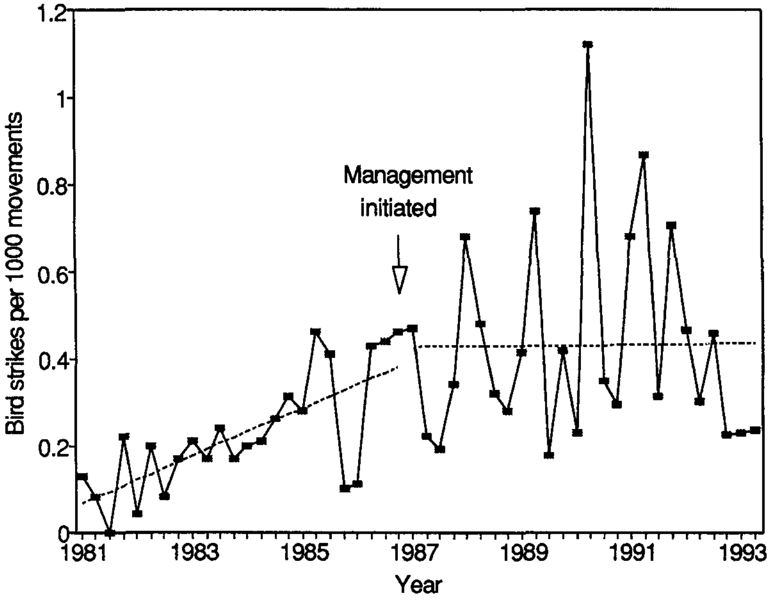

Fig. 4 Variation in quarterly bird-strike rates at Christchurch International Airport from 1981 to 1993. An intensified bird management programme was initiated at the airport in 1987; trend lines were calculated using separate linear models for the pre- and post-management periods (P = 0.003 and P = 0.8, respectively).

127, respectively), Whisper Jets (20 and 27), and Boeing 767s (7 and 5). On the basis of 1993 schedules, 737s arrived or departed at least 200 times daily, as against about 50 times for Whisper Jets and 3–5 times for 767s. This suggests that, on a per-flight basis, 737s are less likely to be involved in strikes than are the other two aircraft types ($\chi^2 = 11.3$, d.f. = 1, $P < 0.001$). Furthermore, the lower strike:miss ratio of 737s relative to the other two aircraft (0.35:1 versus 0.84:1, $P = 0.004$) may indicate that birds are better able to take evasive action with this type of aircraft than with the quieter 767s and Whisper Jets.

In the early 1980s, before bird management was intensified, the number of bird strikes was increasing annually by an average of 5.4 ± 1.2 SE strikes per 100 000 aircraft movements (Fig. 4; $P = 0.003$). Since a local urban refuse dump closed and new bird management practices were implemented in 1987, this increase has no longer been evident ($P = 0.8$), and strike rate has fluctuated around a mean of 43 ± 5 per 100 000 movements. However, the variation in quarterly bird-strike rates has increased significantly (variances of log-transformed data compared; $P = 0.03$). This variation was not due to any statistically significant variation between seasons ($P = 0.1$), so its cause remains obscure.

Without intensified management and surrounding land-use changes, bird strikes would perhaps have continued to increase at the pre-1987 rate. If so, the number of bird strikes saved by the new management practices can be estimated at 16 per 100 000 departures, or about 60 strikes between 1987 and 1993. This assumes about 66 000 movements of commercial and military aircraft at CIA annually (CIA unpubl. data). On a minimum estimate of bird management costs over this period ($16 000 per annum; H. McCarroll pers. comm.) this represents a cost of about $1600 per strike saved, which is almost twice the direct cost of repairing a typical Boeing 373 bird strike at Air New Zealand Engineering Services ($870; B. Richards pers. comm.). However, this calculation underestimates the benefits of bird control, because the repair cost estimate does not consider lost flight time, passenger disruption, and the increased risk of a serious incident occurring.

DISCUSSION

Hone (1994) reviewed three methods of studying bird strikes: pilot incident reports, bird carcass counts, and computer simulation. Examples of pilot report analyses include van Tets (1969) and Burger (1985). Monitoring of the bird control programme at CIA also relies on pilot reports. It is clear that pilots do not report all strikes (at J.F.K. Airport in New York these reports represented only 20% of the true strike rate—Burger 1985). CIA monitoring therefore assumes that the reporting rate remains relatively constant (H. McCarroll pers. comm.). There has been concern that bird incidents raise the reporting rate of other incidents in subsequent days. This was not supported by our analysis (Fig. 1), which suggests that the reporting of bird incidents by pilots does not vary with time since the last reported bird strike.

Assessment of bird species is not a particularly reliable aspect of CIA's bird-strike database. Small-bodied birds are probably under-identified relative to more readily distinguished species such as gulls, harriers, and waterfowl. Nevertheless, it is clear that numerous species can be involved in strikes. In Australia and Papua New Guinea, birds weighing <900 g cause 94% of reported strikes (van Tets et al. 1977). If species composition of the strikes became an issue in future, CIA could consider carcass count data to supplement the pilot incident reports, such as in Burger (1985).

Gulls, sparrows, and plovers were all abundant in the vicinity of the airport, and were the most commonly struck birds. Although having the highest strike rate, sparrows are relatively unlikely to cause serious damage to aircraft (A. Chudleigh pers. comm.). In comparison, plovers had a lower strike rate but are more likely to cause significant damage because of their larger size. The high plover strike:miss ratio may be due in part to aspects of their behaviour; they have strong group territorial behaviour, and have been observed to fly directly at planes (Harper & Carter 1986). Gulls have the highest number of incidents but a low strike:miss ratio. This may be due to their more solitary flying behaviour (pers. obs.), which may make them less likely to be hit than flocking birds such as sparrows. Any additional bird control measures might therefore be most effective if aimed at plovers and sparrows.

Temporal and seasonal patterns in bird-strike rates

The diurnal pattern of bird strikes shows a peak mid-morning, largely due to a peak in the number of sparrow strikes. This peak, which also occurs at J.F.K. Airport (Burger 1985), coincides with the peak activity levels of sparrows and finches reported by Hayes et al. (1989). Gull strikes tended to peak later in the day, which does not correspond with their peak abundance at the airport as reported by Hayes et al. (1989). However, since 1989, a refuse dump adjacent to the airport grounds has been closed and the feeding routine at a nearby pig farm has been altered (G. Lindsay pers. comm.). This may have resulted in a change in the diurnal pattern of gull abundance at CIA.

High rates of bird strike in April coincide with a peak in bird abundance at the airport (Moeed 1976; Hayes et al. 1989). These authors suggested that large numbers of fledglings were on the airport grounds at this time. Inexperienced birds may not have learned adequate aircraft-avoidance behaviours and therefore are at higher than usual risk of being hit (Moeed 1976). Young gulls were more likely than old gulls to be struck at J.F.K. Airport (Burger 1985).

Moeed (1976) suggested that the numbers of finches and sparrows present is low in April, but our data suggests that sparrows and finches are over-represented in the strikes reported in April relative to other months. It may be that these species are being attracted to increased amount of grass seed in late summer, due to the airport's new policy of keeping the grass long around the runways to deter birds from landing (J. C. White pers. comm.), with a subsequent tendency for hawks—feeding on insects, granivorous birds, and rodents—also to increase. Further studies at CIA would be required to confirm these speculations, but several studies elsewhere have shown high correlations ($r > 0.99$) between bird-strike rates and estimates of their abundance in the vicinity of airports (van Tets 1969; Burger 1985).

Aircraft strike patterns

Boeing 737s were the most frequently hit aircraft type but are also the most frequent fliers. Whisper Jets had a higher number of strikes and strike:miss ratio relative to their flight frequency. This may be a result of their flight pattern, which is generally lower and slower than that of 737s (M. Butledge pers. comm.). Boeing 767s fly infrequently but had the highest proportion of strikes. We suspect that this may be due to their large size requiring them to make more extensive use of the runway. Birds are often concentrated at the ends of the runways (Hayes et al. 1989), where they may be struck by "jumbo" jets and other aircraft with long take-off distances.

Burger (1985) found that wide-bodied aircraft such as Boeing 747s and DC10s were more likely to strike birds than were narrow-bodied ones. Relatively few bird strikes were recorded for small planes at CIA, but we did not have access to the aircraft movement data needed to calculate strike rates for small aircraft that would have been comparable with that for the larger airliners.

Effectiveness of management practices

Bird-strike trends have altered significantly since new management practices for the airport and surrounding land were initiated in 1987. The management practices put in place were: sowing of lucerne; decreased mowing and soil quality enhancement to allow greater length in vegetation; active bird patrols and deterrents, shooting, bird alarm calls, hawk kites; and pilot awareness programmes (G. Lindsay pers. comm.). Surprisingly, management practices appear to have destabilised the strike rate, not decreased it, resulting in large fluctuations, which have no strong seasonal pattern. There are no obvious reasons for these wide fluctuations, but their correlation with general regional climate patterns, new agricultural or horticultural developments, changes in nearby agricultural practices, such as ploughing or border dyke irrigation, or even changes in pilot opinions of what constitutes a strike should be tested. If the high bird-strike rates are to be decreased, the causes of these fluctuations need to be determined.

From our analysis of the costs involved in the bird-strike programme, we estimate that more is being spent on avoiding bird strikes than the direct repair costs incurred from bird-strike damage. However, reduction of the chance of fatalities occurring through bird strikes is a priority commitment to airlines, so data on all relevant requirements are needed before a full cost-benefit analysis can be undertaken.

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