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Abstract

It is well known that, at least in the Northern Hemisphere, there is a strong seasonal element in the annual pattern of bird strikes. This study undertakes a statistical analysis of an 11year data set collected at Dublin Airport, Ireland. It attempts to identify statistically significant trends in the seasonal trajectories of bird strikes, both in general and in respect of individual species and in comparison with seasonal trends in the abundance of birds generally and at Dublin Airport in particular. Hypotheses relating to the idea of "open" (i.e. intervals of through-put of naïve and young birds) and "closed" (i.e. intervals when throughput is declining or at a minimum) periods are tested. The results are discussed in the context of the probable ability of birds to learn to avoid aircraft. If birds possess a spatio-temporal memory then it is likely that this ability, or the lack of it, may explain some of the observed trends in the seasonal distribution of bird strikes.

Introduction

It is now known that birds possess a sophisticated memory which, at least in the Corvidae, involves a strong spatio-temporal component (Kamil and Jones 1997). The ability to memorize information obviously allows for the possibility of learning. Cognitive skills, in turn, have obvious survival value which itself is a key property of individual fitness (Newton 1989). Since collisions with aircraft invariably lead to the death of the bird the ability of individuals of different species to avoid aircraft will obviously increase their chances of survival.

Recent evidence has confirmed that birds actively avoid moving commercial aircraft (Kelly *et al*. 1999, 2000 and Kelly *et al*. In press). Earlier Wang and Frost (1992) had shown that neurons in the *nucleus rotundus* of the brain of pigeons (*Columba livia* var *domestica*) are responsible for calculating the "time to collision" (ttc) of approaching objects. Subsequently Sun and Frost (1998) showed that one set of neurons within the *nucleus rotundus* respond exclusively to large objects.

Thus it would appear that in addition to the sophisticated episodic memory of birds together with their ability to learn "geometrical relationships among landmarks" and the possession of neurons which differentially respond to approaching large objects, they have developed the ability to avoid moving aircraft. Moreover, it is likely that these latter skills may be, at least partly, learned and thus will show improvement with increasing exposure to large moving threatening objects, although this hypothesis remains largely untested.

Cresswell (1993, 1994, 1997) and Creswell *et al*. (2000) when looking at the interaction of birds with their avian predators, distinguished between "open" and "closed" intervals within the annual cycle. A closed interval is one in which there is relative stability in bird numbers with comparatively little turnover within the population. The open interval is marked by a sharp increase in the numerical strength of the bird populations coupled with a major throughput of birds – generally on migration.

This model of open and closed intervals can also be applied to birds at airfields. For example, there will be a marked increase in the number of birds during the post-breeding and migration periods in late summer/autumn, whereas the numbers will remain relatively constant during the winter period from November through to March.

The aim of this study was to test the hypothesis that the number of bird strikes would be demonstrably greater during the open intervals. This objective can be seen as a preliminary test of a more general hypothesis that birds learn to avoid aircraft.

Methods

All of the data analysed in this paper was collected at Dublin Airport ($53^0$25'N, $06^0$16'W, 74 m asl) between January 1990 and December 2000. Only bird strike incidents that satisfied the criteria set out in Kelly *et al.* (1996) are included in this study. All bird cadavers were stored in a deep-freeze until their identification was confirmed. Three time intervals are distinguished for the purposes of this study.

(i) Open Spring (March to June inclusive). This interval is identifiable by the migration northwards of – mostly - adult birds together with the first emergence of fledgling birds breeding locally.

(ii) Open Autumn (July to October inclusive). This period is identified by the continued arrival of young birds and the increasing throughput of migrants many of which are juveniles. It is likely that for individual birds the duration of stay is short.

(iii) Closed Winter (November to February inclusive). Although the number of birds remains relatively constant the population size is large and composed of many adults. The throughput is likely to be much lower than Open Autumn and the duration of stay of individual birds is probably much longer.

Results

The total numbers of bird-strikes, across all eleven years, was determined for each of the designated intervals, and is shown in Tables 1 and 2.

Table 1. Frequencies of bird strikes at different time intervals (1990 – 2000 inclusive)

Time Interval	***Frequency of Bird Strikes***
Open Spring	112
Open Autumn	204
Closed Winter	69

It would be expected that the underlying frequencies of strikes for each of these intervals (of equal time-duration) would differ and this was confirmed by a chi-square test. One can then proceed to compare the frequencies for each pair of intervals. We viewed the frequency data as arising from a combination of Poisson processes, so that the aggregate counts for each interval have a Poisson Distribution, each with an appropriate value for the Poisson mean. We proceeded to test the equality of these Poisson means, and as expected, found that the differences were statistically significant.

This analysis was repeated for one particular species, the Black headed Gull *Larus ridibundus*, and the corresponding frequencies are contained in Table 2.

Table 2. Frequencies of Black headed Gull strikes at different time intervals (1990 – 2000 inclusive)

Time Interval	***Frequency of Strikes***
Open Spring	0
Open Autumn	43
Closed Winter	22

The analysis used above for the aggregate frequencies of bird-strikes was applied here also, and similar results were found.

It is also interesting to look at the patterns of strike frequencies within each of the intervals. Despite the fact that bird populations in neighbouring wet-lands are increasing over the Closed Winter interval, the trend in the strike-frequencies within that interval is declining. Appositely, while bird-populations are declining in the early part of Open Spring, the frequencies of bird-strikes has been found to increase. Most of the bird strikes in this latter interval involve recently fledged birds.

Discussion

There are two periods of active migration in the Boreal Year. The first commences in March and continues through to the end of May. This movement is composed almost exclusively of adult birds. The end of this migration coincides with the emergence of the first brood of juvenile birds fledged in that year.

The second migratory movement commences in late June and continues until at least late October. A high proportion of the birds moving at this time are immatures which are moving south. The numbers of birds continues to be augmented by locally reared recruits. If learning and experience were contributory factors to the frequencies of bird strikes it would be expected that the numbers should rise with the increasing presence of inexperienced birds. This hypothesis is supported by the results of our analysis. However an examination of the within-interval trends suggests that local recruitment of young birds into the airfield environment may be the most important factor explaining the total number of bird strikes.

For the Black headed Gull it does appear that there is a decline in the frequencies of bird strikes during the Closed Winter period, which may indicate that individuals of this species which are not locally recruited gradually learn to avoid aircraft as the winter progresses.

It remains to be demonstrated how different species of birds calculate the time to collision for objects of the size of commercial jet aircraft. Although Sun and Frost (1998) have shown that a particular type of neuron responds exclusively to large looming objects there is no evidence as yet that such pathways are present in the species which show avoidance movements at Dublin Airport.

It is possible that other factors also contribute to the observed pattern of between - and within – interval variation in the frequencies of bird strikes. These factors include weather, length of daylight, numbers and types of aircraft movements, bird scaring operations and annual variation in breeding success. It is now well established that there are “good” and “bad” breeding years. It is also known that a high proportion of the strikes involve immature birds (e.g. Kelly *et al*. 2001 In press). Therefore, in addition to the above-mentioned factors, detailed information on the proportion of immatures in the population will be necessary to explain variation in the frequencies of bird strikes.

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