ANNALES
UNIVERSITATIS MARIAE CURIE-SKŁODOWSKA
LUBLIN – POLONIA
VOL. XXXII (1) SECTIO EE 2014

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Bird strikes at Polish civil airfields – the importance of ecological factors in risk management

Kolizje samolotów z ptakami na lotniskach cywilnych w Polsce – znaczenie czynników ekologicznych w zarządzaniu ryzykiem

Summary. The analysis concerned the ecological aspects of 191 aircraft bird strikes at Polish airfields in 2006–2009. Of the identified birds, collisions most often involved swallows and martins, Eurasian kestrels, and gulls. The species with the highest weight involved in bird strikes were the mute swan and the white stork. Bird strikes were more frequent during the landings than during the take-offs. Birds most frequently hit the engines and fuselages of planes. The highest proportion of bird strikes occurred in July and August (41.0%). Those bird strikes during which multiple structural elements were simultaneously hit most often (92.0%) took place in the June–September period.

Key words: bird strikes, airfields, environmental security, risk management

INTRODUCTION

Bird strike analyses based on a large number of cases unambiguously show that the vast majority among them take place at airfields [Richardson and West 2005, Cleary *et al*. 2006, ENAC and BSCI 2007]. The issues of bird strikes are rarely considered in terms of their ecological dimension, extremely helpful in the effective management of bird populations towards a reduction of bird strike risk [Matyjasiak 2008, Soldatini *et al.* 2008, Kitowski *et al.* 2010].

Disturbance effects from aircraft operation and human activities may be negligible for some bird species; often they habituate to acoustic disturbance and maintain their typical behavioral patterns [Conomy *et al.* 1998]. Some studies showed that at disturbed sites, lower densities of birds may result in higher foraging success because of lower competition for the same resources [Mallord *et al.* 2007, Sutherland 2007]. European airfields, due to the way vegetation is managed there, may be treated as converted meadows. This to a large extent determines the context and dynamics of the processes taking place there with reference to bird strike risk management. The present study aims to analyze the ecological aspects of aircraft bird strikes based on raw reports of the Polish State Commission on Aircraft Accident Investigation (PSCAAI), helpful in risk management, at the airfields.

MATERIALS AND METHODS

Cases of bird strikes from 2006–2010 at 12 Polish airfields were analysed in the present article. The case analyses were based on raw reports produced by the Polish State Commission on Aircraft Accident Investigation (PSCAAI) affiliated with the Ministry of Infrastructure. They have been made available as PDF files on the websites of this Commission (www.mi.gov.pl) as well as at the portal called: PortaldlaPilota (www.dlapilota.pl). Since a large number of collisions with bird flocks were reported, during which multiple structural elements of aircrafts were simultaneously hit, the frequency relating to particular elements being hit was analysed with reference to the total number of elements getting hit, not with reference to the number of collisions. The codes of the airports mentioned in the article are given after International Civil Aviation Organization (ICAO). Bird weights are given after Jedrzejewska and Jedrzejewski [1998]. For the purposes of statistical analyses, chi-square with Yates corrections and Fisher exact tests were used [Sokal and Rohlf 1981]

RESULTS

Species composition

For 74 cases of bird strikes, the taxonomic identity of the birds involved was established on the family level at least. This constituted 38.8% of all the bird strikes analysed here (Tab. 1). In total, 20 taxa of birds participated in bird strikes (Tab. 1). A considerable proportion (about one third) of all the cases of bird strikes involved the following species of the identified birds: Eurasian Kestrels *Falco tinunnculus*, Martins and Swallows Hirundinidae, Gulls Laridae, Buzzards *Buteo* sp. and Pigeons Columbidae (Tab. 1). Among the reported collisions involving Gulls, as many as 66.7% took place at Warsaw Airport (ICAO: EPWA), and as many as 35% of bird strikes involving Hirudinaea took place at Krakow Airport (ICAO: EPKK). Also notable are collisions with Pigeons, including 2 cases of bird strikes involving ringed Pigeons *Columba livia*. The heaviest of the birds that hit aircrafts were Mute Swan *Cygnus olor* (12.0 kg) (two events at Gdansk-Rebiechowo, ICAO: EPGD) and White Stork *Ciconia ciconia* (3.5 kg) *(*EPWA) Apart from collisions with flocks consisting of one bird species, aircraft collisions with two-species flocks occurred. One of those involved a mixed flock of Gulls and Terns *Sterna* sp. at Poznan Airport (ICAO: EPPO). The other one was a collision of a B-738 aircraft with a foraging flock of Starlings *Sturnus vulgaris* and a Grey Heron *Ardea cinerea* at Rzeszow International Airport (ICAO: EPRZ).

Table 1. Birdstrikes victims sorted by number
Tabela 1. Ofiary kolizji z samolotami

Taxa – Taksony	N	%
Hirundinidae	26	13,60
Falco tinnunculus	15	7,85
Larus sp.	6	3,14
Buteo sp.	4	2,10
Columbidae	4	2,10
Motacilla sp.	3	1,60
Cygnus olor	2	1,05
Anas sp.	2	1,05
Apus apus	2	1,05
Ciconia ciconia	1	0,52
Accipiter gentilis	1	0,52
Vanellus vanellus	1	0,52
Strigiformes	1	0,52
Alauda arvensis	1	0,52
Sturnus vulgaris	1	0,52
Corvus frugilegus	1	0,52
Passer sp.	1	0,52
Larus sp. + *Sterna* sp.*	1	0,52
Sturnus vulgaris + *Ardea cinerea**	1	0,52
Indeterminate taxa Taksony nieokreślone	117	61,26
Total – W sumie	191	100

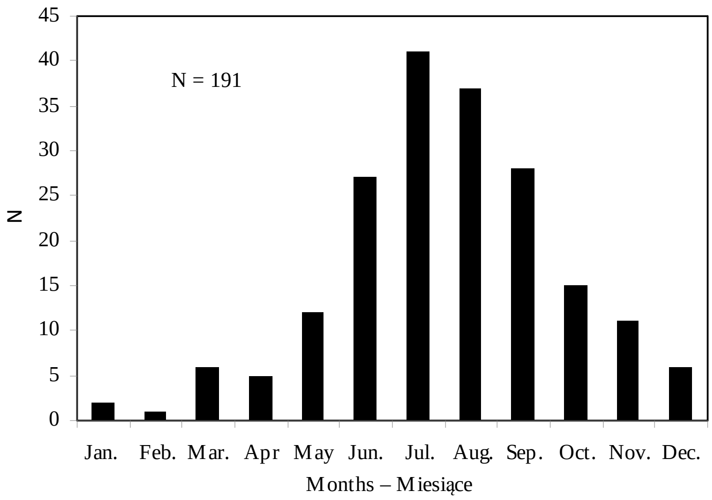
N – number of collisions – liczba kolizji.
* Multispecies birdstrikes – kolizje angażujące więcej niż 1 gatunek ptaka.

Bird strikes by stage of flight

The greatest number of the observed bird strikes (121, 63.4%) took place in the context of landing procedures (descent, approach, landing, and landing roll). The number of collisions taking place during take-off procedures (take-off run, take-off, climb) was smaller, amounting to 67 (35.1%). The difference between landings and take-offs in the frequency of bird strikes was highly significant: ($\chi^2 = 13.05$, df = 1, $p < 0.00001$). In only two cases did birds hit aircrafts during taxiing, and in one case the context of the bird strike remained unspecified (1.5%).

Seasonal aspects of bird strikes

The frequency of bird strikes was observed to vary noticeably during the year (Fig. 1). Statistically significant differences were found between seasons ($\chi^2 = 13.05$, df = 3, $p = 0.004$). The highest number of bird strikes – a total of 159 (83.2%) – were reported in summer and in autumn (in the period from June to November) (Fig. 1). The safest months were January and February, with a joint total of 3 (1.6%) bird strikes. The most dangerous months to air traffic were July and August, when a total of 78 (40.8%) bird strikes were reported.



N – number of birdstrikes – liczba kolizji z ptakami

Fig. 1. Monthly distribution of birdstrikes (N = 191) at polish civil airfields from 2006–2010
Ryc. 1. Miesięczna frekwencja kolizji ptaków z samolotami (N = 191) na lotniskach w Polsce latach 2006–2010

llisions with bird flocks

Among the reported bird strikes, 39 (20.4%) were collisions with bird flocks. The highest number of such collisions – as many as 8 (20.5%) – took place in August. The frequency of collisions with bird flocks was higher in the migration period (February-March and July-November) compared to the breeding period (April-June): 30 (76.9%) *vs* 8 (21.1%) (χ^2 = 12.7, df = 1, p = 0.004). Their number was 9 times higher during the spring migration than during the autumn migration: 27 *vs* 3 cases. However, the proportion of such collisions in the overall number of bird strikes did not differ significantly between the migration period and the breeding period: 30 (21.6%) *vs* 8 (18.2%) (χ^2 = 0.07, df = 1, p = 0.786). There was no significant difference, either, between the percentage of multiple bird strikes taking place in the context of landings and the percentage of those occurring in the context of take-offs: 24 (19.8%) *vs* 14 (20.9%) (χ^2 = 0.001, df = 1, p = 0.987). Notable among collisions with bird flocks are multiple bird strikes, meaning those collisions in which more than one of the aircraft's structural elements gets hit. The 13 multiple bird strikes were reported, constituting 6.8% of all the cases analysed here and as many as 30.8% of collisions with bird flocks. Multiple bird strikes occurred in the period from March to September. However, as many as 12 of them (92.3%) happened after breeding, in the June-September period.

Bird strikes by part damaged

For 92 bird strikes, the parts of aircrafts hit by birds were reported. Because 13 collisions (14.1%) were multiple bird strikes, we know 105 places that were hit by birds (Tab. 2). Considering all the structural elements, we notice that, in summer, birds most frequently hit the fuselages and noses of planes (Tab. 2).

Table 2. Bird strikes by parts damaged during particular seasons of the year
Tabela 2. Frekwencja kolizji z ptakami w zależności od uszkodzonego elementu konstrukcyjnego w poszczególnych porach roku

Part damaged Uszkodzone elementy	Winter Zima	Spring Wiosna	Summer Lato	Autumn Jesień	N	%N
Engines Silniki		5	10	11	26	24,8
Fuselages Kadłuby	1	2	13	3	19	18,0
Noses Nosy		2	12	3	17	16,2
Cockpits Kokpity			9	5	14	13,3
Wings Skrzydła		2	8	1	11	10,5
Gears Podwozia	1		5	2	8	7,6
Propellers Śmigła	1		2	2	5	4,8
Radomes Osłony radarów			1	1	2	1,9
Lights Światła			2		2	1,9
Tails Ogony		1			1	1,0
Total W sumie	3	12	62	28	105	100

Aircraft fuselages were affected by bird strikes more often in summer than in autumn: 13 (21.0%) *vs* 3 (10.7%). The difference was not significant: Fisher test (one cut) $p = 0.194$. The situation was similar in the case of plane noses, which were hit 12 times in summer (19.3%), and only 3 times in autumn (10.7%). The difference was not significant, either: Fisher test (one cut) $p = 0.191$. An opposite tendency was observed for engines. Engines were more often hit in autumn than in summer: 11 (39.3%) *vs* 10(16.1%), respectively – and the differences in frequency were found to be significant ($\chi^2 = 4.56$, df $= 1$, $p = 0.033$). It should be stressed that engines constituted the highest percentage

(41.7%) of all the structural elements hit in spring (Tab. 2); as regards other seasons, the corresponding rate for engines was the lowest in summer. The differences were close to statistical significance: Fisher test (one cut) $p = 0.058$. It is also worth stressing that engines were hit in as many as 8 (61.5%) out of 13 multiple bird strikes.

DISCUSSION

The species composition in aircraft bird strikes in Poland appears to be typical for the countries of Central Europe. Just like in other countries of this part of Europe (the Czech Republic, Slovakia, Lithuania, and the eastern part of Germany), the following species were most often identified as perpetrators of bird strikes: Gulls, Martins and Swallows, Pigeons, Wagtails, Swifts, Kestrels, and Buzzards; Starlings, Rooks, Ducks, and White Storks were also found [Murar 1994, Zalakevicius 1994, Jacoby 1998, Krupka 2000, Kitowski 2011].

In other parts of Europe, depending on the species composition of the taxons occurring there and on the local conditions, various species threaten aircrafts. There is a tendency for Ducks, Swans, and Geese to be more involved in bird strikes in the northern part of Europe [Andersson, 2006, Aas 1996, Shergalin 1992], and collisions involving vultures Aegypiinae occur exclusively in the south of Europe [Manueco 1992, Nikolaidis 2003]. Countries connected with coasts are also characterized by a high frequency of collisions involving Gulls [Aas 1996, ENAC and BSCI 2007]. Regardless of geographical location, a high proportion of diurnal birds of prey in aircraft bird strikes is reported in Europe [Krupka 2000, Breuer 2005, ENAC and BSCI 2007].

Two of the analysed bird strikes from Poland concerned ringed Pigeons. Domestic Pigeons are also responsible for tragic collisions with Polish military aircrafts (in 1962: a TS Iskra jet, and in 1983: a navy helicopter Mi-14PL) in which 4 people got killed [Szymczak 2009, Kitowski 2011]. In Poland, pigeon keeping near airfields is still a problem for air traffic, one that remains unresolved for many years [Bonczar 2009, Kaminska 2009, Kitowski *et al*. 2010]. Even though legal regulations restrict the possibility of keeping Pigeons in the proximity of airfields, they are not effectively enforced. Apart from the presence of domestic Pigeons at airfields, bird strike risk (particularly from Gulls and Corvids) is increased by the practically unlimited possibility of locating large waste dumps in their vicinity. Legal and illegal waste dumps are situated in the proximity of a considerable proportion of Polish airfields, both civil and military [Dzik and Kiernicki 2005, Kaminska 2009, Bonczar 2009, Kitowski *et al.* 2010]. In many cases, this results from the lack of goodwill on the part of local authorities. For example, the runway of EPWA airport, Poland's main airfield, is located only 420 m from a large waste dump. We must admit, though, that problems resulting from waste management facilities being located near airfields by local authorities are equally difficult elsewhere in the world. They also show that the liquidation of specific facilities may be a process lasting many years, despite the threat to air traffic [Ayalon *et al*. 2006, Stenman *et al.* 2007].

Poland boasts the largest breeding population of the White Stork (up to 49 thousand of breeding pairs) [Neubauer *et al.* 2011]. Unfortunately, they constitute a serious threat to civil aviation. Military aviation has reported serious collisions involving these birds as well [Dzik and Kiernicki 2005, Kitowski 2011]. Still, the country where bird strikes involving White Storks are the most serious, the most damaging to aircrafts, and the most deadly to pilots is Israel [Ovadia 2005]. At some Polish airfields, bird strikes were reported involving water birds, such as Gulls, Ducks, Swans, and Grey Herons (Tab 1). This reflects the local problems of Polish airfields, resulting from their unfortunate location in vicinity of river valleys (EPWA), sea coasts (EPGD) or fish ponds (EPKK) [Dzik and Kiernicki 2005, Bonczar 2009, Kaminska 2009]

Airfield areas are regularly mown in Poland, and the application of Long Grass Policy (LGP) remains a constantly re-submitted proposal [Kitowski 2011]. Unfortunately, short grass encourages birds to forage, since it makes it easier to locate and access food as well as facilitates social relations between foraging birds [Deacon and Rochard 2000]. The mown surfaces of Polish airfields are conducive to the intensive social foraging of some species in the period before breeding and the autumn migration [Bonczar 2009, Kaminska 2009, Kitowski *et al*. 2010], which clearly affects the species composition of bird strikes. At numerous airfields in Europe failure to apply LGP procedures also appears to be a possible cause behind bird strikes involving Gulls, European Starlings, Lapwings *Vanellus vanellus*, Buzzards, Kestrels, Rooks, and White Storks [Murar 1994, Zalakevicius 1994, Jacoby 1998, Krupka 2000, Breuer 2005, ENAC and BSCI 2007].

Information on the phenology of bird strikes may be of fundamental significance to the processes of bird strike risk management at airfields. The largest number of bird strikes at Polish civil airfields took place in summer. The above data corresponds to that which is available for military aviation. Szymczak [2009] reports that 46.6% of military bird strikes happened in the June-August period. The autumn-winter period as well as spring were safer for Polish military aircrafts. This tendency is also reflected in other data from Central Europe. An analysis of civil bird strikes from Lithuania revealed that as many as 73% of them took place between June and October, with a peak in July [Zalakevicius 1994]. The distribution of bird strikes between different months for Czech military aviation showed a marked critical period in August [Krupka 2000]. In the neighbouring Slovakia the highest number of bird strikes happened from August to September [Murar 1994]. Nearly 90% of bird strikes involving Soviet aircrafts based in East Germany, Poland's neighbour during the Cold War, took place in March as well as in late July and early August [Herzog 1997]. Wiede [2003] reports that the number of military bird strikes for the whole area of Germany in 1992-2001 was the highest in the June–October period and the lowest in winter. Reports from the south of Europe (Italy, Greece) also indicate a smaller risk in winter [ENAC and BSCI 2007, Nikolaidis 2003]. The above data indicates that the winter period may be regarded as safer to air traffic in Europe since many species leave that continent for this time, with the result that the abundance, mobility, and biodiversity of its avifauna becomes considerably impoverished. Analysing nearly 65 thousand bird strikes from 1990–2005, Cleary *et al*. [2006] point to the July–October period as the most dangerous time for air traffic in the USA. As many as 51% of all bird strikes happened then.

Observation of bird strikes at Polish airfields shows that such accidents mainly occur after the breeding season of birds is over. Because of this, they may result from the inexperience of young birds in avoiding aircrafts [Anderson and Osmek 2005]. Still, no significant difference was found in the rate of collisions with bird flocks between the migration and breeding periods. This is due to the fact that the mobility of adult birds connected with intensive searching for food for themselves and their offspring may act as a factor increasing bird strike risk in the breeding period. Authors recommend catching young stationary inexperienced birds from airfield areas in order to avoid bird strikes while at the same time leaving stationary adult birds, experienced in avoiding aircrafts [Anderson and Osmek 2005, Stenman *et al*. 2007].

During aircraft bird strikes at civil airfields in Poland, birds most often hit engines and fuselages. Szymczak [2009] reports that in the years 1982–2000, in military bird strikes, the elements most often hit were engines (34%), fuselages (22%), and wings (12%). During 176 military bird strikes reported in the neighbouring Czech Republic, birds most often hit engine inlets and engines (37.5%). Noses (21%) and radars (17.1%) were hit much less often. The remaining 24.4% of bird strikes involved birds hitting other structural elements, such as fuselages, landing gear, etc. [Krupka 2000]. Breurer [2005] analysed 2395 civil bird strikes from Germany. The elements damaged in the highest number of collisions were engines, fuselages, cockpit windows, aircraft noses, radomes, and wings: (18.8%), (17.2%), (15.1%), (15.0%), and (10.8%), respectively. Other structural elements, mainly landing gear, were less often hit by birds (9.3% in total). Cleary *et al*. [2006] analysed nearly 60 thousand bird strikes from the USA from the years 1990–2005, the highest number among which were cases of birds hitting cockpit windows (17.0%), engines (15,0%), and aircraft noses (14%). During 13.0% of collisions the elements hit were wings/rotors and fuselages. In 12% of collisions, it was random that got hit. During the remaining 16.0% of bird strikes the birds hit the landing gear, tails, propellers, etc.

Civil aircrafts at civil airfields in Poland tended to get hit by birds more often during the landing procedure. Analysing 48638 cases of bird strikes from the USA from 1990-2005, Cleary *et al*. [2006] report that the highest proportion of bird strikes (39%) were observed during approach. A smaller percentage was reported during take-off (20%) and climb (18%). Only 16% of bird strikes took place during the landing roll. En route and during descent, aircrafts were hit by birds in only 3% and 4% of cases, respectively. The remaining cases concerned parked or taxiing machines [Cleary *et al*. 2006]. Breurer [2005] analysed nearly 2080 cases of bird strikes from Germany for which the context was known. During take-off runs and take-offs 21.8% of accidents happened. Slightly more bird strikes – 24.8% – took place during landing and landing roll. At the civil airfields of Italy, as many as 61% of bird strikes occurred during landing procedures and 38% in the context of take-off procedures [ENAC and BSCI 2007].

Bird population trends may affect the frequency of bird strikes. The population size of some of the species that used to pose a problem to aircrafts in Poland is decreasing. A good example is the Rook *Corvus frugilegus*, very often using Polish airfields as foraging areas [Bonczar 2009, Kaminska 2009, Kitowski *et al*. 2010]. Recent surveys revealed a marked decrease in its population size [Neubauer *et al*. 2011]. Similar processes were reported [Neubauer *et al*. 2011] for the population of another species frequently observed at airfields in Poland [Bonczar 2009, Kaminska 2009, Kitowski *et al.* 2010] – namely, for the Lapwing. On the other hand, the populations of big bird species connected with wetlands, such as the Crane *Grus grus*, the Greylag Goose *Anser anser*, the Whooper Swan *Cygnus cygnus*, and the Mute Swan – which constitute an exceptionally serious threat to air traffic in Europe [Kitowski 2011] – have been increasing in Poland [Neubauer *et al*. 2011]. Yet, in the case of Black-headed Gulls *Chroicocephalus ridibundus* – a species frequently observed at Polish airfields and known to hit aircrafts [Kitowski *et al*. 2010] – the decreasing trend from the last dozen or so years has probably been stopped [Bukacinski *et al*. 2007].

CONCLUSIONS

In conclusion, it must be stressed that the system of managing bird populations at airfields is, in fact, only beginning to develop in Poland. The management of animal populations is only starting to be implemented; still, numerous airfields already use proscrupine systems, bird sonic systems, or gas cannons. Large civil and military airports are also protected by falconers [Kaminska 2009, Kitowski *et al*. 2010]. Apart from the need for introducing new techniques of birdstrike risk management such as lasers, the use of Border colli breed dogs, and Long Grass Policy, there is a need for ornithological monitoring of airfield areas and their vicinity. Unfortunately, this has been implemented at few facilities, e.g. those in Poznan or Krakow [Kitowski 2011]. It is also urgent to train air traffic safety managers to recognize birds. Regrettably, the lack of knowledge about the ecology of the species that hit aircrafts and the practically voluntary system of reporting bird strikes has been a problem that is bound to take Polish risk managers many years to solve. Many of the problems discussed here stem from the fact that analyses devoted to the environmental determinants of the functioning of Polish airports overlook the presence of birds as a flight safety factor. Unfortunately, this happens at the local as well as regional levels [Komornicki and Sleszynski 2009].

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Streszczenie. W pracy przedstawiono analizę ekologicznych aspektów 191 kolizji ptaków z samolotami na lotniskach cywilnych w Polsce w latach 2006–2009. Spośród zidentyfikowanych ptaków najczęściej kolizjom z samolotami ulegały: jaskółkowate Hirundinidae, pustułki *Falco tinnunculus* oraz mewy Laridae. Gatunkami o największej masie, które zderzyły się z samolotami, były łabędź niemy *Cygnus olor* oraz bocian biały *Ciconia ciconia*. Kolizje z ptakami były częstsze niż podczas startów. Ptaki najczęściej uderzały w silniki i kadłuby samolotów. Największy odsetek wszystkich odnotowanych kolizji przypadał na lipiec i sierpień, w sumie 41%. Natomiast najwięcej kolizji ze stadami ptaków było w okresie czerwiec – wrzesień.

Słowa kluczowe: kolizje samolotów z ptakami, bezpieczeństwo środowiskowe, zarządzanie ryzykiem