

CRANFIELD UNIVERSITY

**Analysis of the Bird Strike Reports Received by the
Finnish Transport Safety Agency between the Years
2000 and 2011**

Mr. Jukka-Pekka Nikolajeff

School of Engineering

MSc Thesis

Cranfield University

School of Engineering

MSc Thesis

Academic Year 2012-2013

Mr. Jukka-Pekka Nikolajeff

**Analysis of the Bird Strike Reports Received by the
Finnish Transport Safety Agency between the Years
2000 and 2011**

Supervisor: Mr. Rodney Fewings

December 2013

This thesis is submitted in partial fulfilment of the requirements for the
degree of Master of Science.

Abstract

As soon as people started to fly, bird strikes became a significant safety issue. At present, hundreds of bird strikes are reported every year, and the consequences vary between a scared pilot to a total aircraft hull loss. It has been estimated that the material cost of bird strikes may be more than one billion Euros annually. But in addition, there is the immeasurable cost of losing human lives.

How could we fly safely sharing the same sky with the birds? The question is difficult to answer because of the complex reasons why bird strikes happen. The increasing number of flights and growing bird population will also bring new challenges in the future.

This thesis approaches the subject by concentrating on the benefits of bird strike reporting in Finland. The thesis reviews all bird strike reports received by the Finnish Transport Safety Agency between the years 2000 and 2011. According to this data, the number of bird strike reports has been increasing significantly during the past few years. Unfortunately, at the same time, the quality of bird strike reports has been decreasing in Finland.

Based on the reports analysed, the importance of good bird strike reporting was not yet clear for all stakeholders. The bird species were often poorly identified, and a lot of other valuable data, such as weather details, were frequently missing from bird strike reports. In addition, bird strikes that did not cause any damage were often not reported. This was because bird strike reporting is not yet mandatory in Finland. The aim in bird strike reporting should be better quality and higher frequency than what is currently found in Finland. This could certainly improve aviation safety.

Acknowledgements

First I would like to thank my Supervisor Mr. Rodney Fewings. He showed great flexibility, understanding and support, giving me valuable comments whenever I was asking. It was an honour to be supervised by him.

Many thanks to all those people who supported me when I was writing my thesis. I would especially like to thank my colleagues at the Finnish Transport Safety Agency's Analysis Department. They managed to listen to my bird strike stories day after day as if they were really interested. I would also like to thank Mr. Pentti Korkalainen and Jussi Sorsa, who attend to the bird strike report files at the Finnish Transport Safety Agency, and Ms. Leila Iikkanen, who kindly helped me when my English was not good enough to write this. Thanks also to the employees of the Finnish airport operator, Finavia Corporation, for giving me all the information that I needed, and thanks to all the members of the Finnish Bird Strike Committee, who always believed that my thesis would be completed in time.

A very special thanks goes to my family and friends. I was always supported by one of them when things were not going so well.

There are no words to tell how grateful I am for this opportunity to study in Cranfield University. For me this has been an adventure to something totally different and new. I would love to thank all the people with whom I was working in the Department of Air Transport. I will never forget the time I spent in Cranfield.

Jukka-Pekka Nikolajeff

Contents:

Abstract.....	i
Acknowledgements.....	ii
Contents.....	iii
List of Figures.....	vi
List of Tables.....	vii
Glossary.....	viii

Chapter 1: Introduction to the Thesis.....1

1.1 Main Reasons to Study Bird Strikes in Finland.....	1
1.2 Methodology.....	1
1.3 Aims and Objectives.....	1
1.3.1 Aims.....	1
1.3.2 Objectives.....	2
1.4 Chapter Structure.....	3

Chapter 2: Literature Review.....4

2.1 Introduction.....	4
2.2 What are Bird Strikes.....	4
2.2.1 Definitions of Bird Strike.....	4
2.2.2 Bat Strikes.....	6
2.3 Which Part of the Aircraft the Birds Normally Hit.....	6
2.3.1 Which Part of the Aircraft is the Most Sensitive.....	7
2.4 Why are Bird Strikes Dangerous.....	7
2.5 Aircraft Certification.....	8
2.6 History of Bird Strikes.....	9
2.7 Bird Strikes – Growing Problem in the Future.....	9

2.8 Altitudes Where Bird Strikes Happen.....	10
2.9 Climate Change and Bird Strikes.....	11
2.10 Understanding the Birds.....	12
2.11 How to Prevent Bird Strikes.....	13
2.11.1 Web-based Bird Avoidance System.....	15
2.12 History of Bird Strike Reporting in Finland.....	16
2.12.1 Bird Strike Reporting in Finland Today.....	17
2.12.2 What is Known about Bird Strikes in Finland.....	18
 Chapter 3: Results.....	20
3.1 Introduction.....	20
3.2 Number of Bird Strike Reports Submitted.....	20
3.3 Types of Aircraft and Engines.....	22
3.4 Time of Day When the Bird Strikes Occurred.....	25
3.5 Phase of Flight When the Bird Strikes Occurred.....	26
3.6 Damage to Aircraft and Effect on the Flight.....	27
3.7 Weather.....	28
3.8 Bird Size and Identification of Species.....	29
3.9 Number of Birds Seen and Number of Birds that Hit the Aircraft.....	32
3.10 Time of Year When the Bird Strikes Occurred.....	35
3.11 Were Pilots Warned about the Birds?	37
3.12 Airports where the Bird Strikes Occurred.....	38
3.13 Altitudes (QNH) Where the Bird Strikes Occurred.....	41
 Chapter 4: Discussion.....	43
4.1 Introduction.....	43
4.2 Reporting of Bird Strikes.....	43

4.3 What Kind of Aircraft is the most Sensitive to Bird Strikes.....	45
4.4 Time of Day When the Bird Strikes Occurred.....	46
4.5 Arctic Migrations.....	47
4.6 Weather.....	49
4.7 Phase of Flight When the Bird Strikes Occurred.....	50
4.8 About Heights and Altitudes.....	50
4.9 Trends.....	52
 Chapter 5: Conclusion.....	54
5.1 Introduction.....	54
5.2 Conclusion of this study.....	54
5.2.1 Quality of Bird Strike Reports.....	54
5.2.2 Quantity of Bird Strike Reports.....	55
5.2.3 Identification of Bird Species	56
5.2.4 Types of the Aircraft and Reported Bird Strikes.....	56
5.3 Recommendations for Future Research.....	57
 References.....	58

List of Figures

Figure 1 - Bird strike reports received by the Finnish Transport Safety Agency.....	21
Figure 2 - All aircraft movements at Finnish airports between 2000 and 2011.....	21
Figure 3.1. - Reported bird strikes and aircraft types involved in years 2000, 2006 and 2011.....	24
Figure 3.2. - Number of bird strikes in relation to the number of aircraft operations.....	24
Figure 4 - Time when bird strikes occurred in years 2000, 2006 and 2011.....	26
Figure 5 - Phase of flight when bird strikes occurred in years 2000, 2006 and 2011.....	27
Figure 6 - Current weather when bird strikes occurred in years 2000, 2006 and 2011.....	29
Figure 7 - Size of bird what hit the aircraft in years 2000, 2006 and 2011.....	31
Figure 8 - Percentage of birds identified in years 2000, 2006 and 2011.....	32
Figure 9.1. - How many birds were seen before strike in years 2000, 2006 and 2011.....	34
Figure 9.2. – Number of birds seen before strike in years 2000, 2006 and 2006, expressed in percentages.....	34
Figure 10 - How many birds really hit the aircraft after observation in years 2000, 2006 and 2011.....	35
Figure 11 - Reported bird strikes by month in years 2000, 2006 and 2011.....	36
Figure 12 - Was pilot warned about birds before strike occurred in years 2000, 2006 and 2011.....	37
Figure 13 - Where bird strikes happened in years 2000, 2006 and 2011	39
Figure 14 - Airports where bird strikes occurred in years 2000, 2006 and 2011.....	40
Figure 15 - Altitudes where bird strikes occurred in years 2000, 2006 and 2011.....	42
Figure 16 - Number of occurrences in ECCAIRS.....	44

List of Tables

Table A1.1 - Aircraft movements at Finnish airports in years 2000, 2006 and 2011.....	62
Table A1.2 - Aircraft movements at Finnish airports between 2000 and 2011.....	63
Table A1.3 - Number of reported bird strikes by type of the aircraft in the year 2000.....	64
Table A1.4 - Number of reported bird strikes by type of the aircraft in the year 2006.....	65
Table A1.5 - Number of reported bird strikes by type of the aircraft in the year 2011.....	66
Table A1.6 - List of abbreviations of aircraft types.....	67
Table A1.7 - Aircraft take-offs and landings at Finnish airports by aircraft and engine category in years 2000, 2006 and 2011.....	69
Table A1.8 - Total aircraft take-offs and landings at Finnish airports by aircraft and engine category in years 2000, 2006 and 2011.....	70
Table A1.9 - List of abbreviations of aircraft and engine categories.....	71
Table A1.10 - Helsinki-Vantaa International Airport (EFHK) wild life management map.....	72
Table A1.11 - Helsinki-Vantaa International Airport (EFHK) wild life actions.....	73
Table A1.12 - Helsinki-Vantaa International Airport (EFHK) type of wild life observations.....	74

Glossary

A/C	Aircraft
AGL	Above Ground Level
ASL	Above Sea Level
ATIS	Automated Terminal Information Service
BASH	Bird Aircraft Strike Hazard
BBC	British Broadcasting Corporation
BSCC	Bird Strike Committee Canada
CAA	Civil Aviation Authority
EASA	European Aviation Safety Agency
EC / EU	European Commission / European Union
ECCAIRS	European Coordination Centre for Accident and Incident Reporting System
GEN	General
GMF	Global Market Forecast
IBSC	International Bird Strike Committee
ICAO	International Civil Aviation Organization
JAA	Joint Aviation Authorities
LMT	Local Mean Time
LT	Local Time
OPS	Operations
QNH	Barometric pressure adjusted to sea level
RPM	Revolutions Per Minute
TGL	Temporary Guidance Leaflet
UK	United Kingdom
USA	United States of America
Vc	Velocity Cruise / Cruise Speed

Chapter 1: Introduction to the Thesis

1.1 Main Reasons to Study Bird Strikes in Finland

Bird strikes in Finland have not been analysed in any previous studies. This study attempts to identify the strengths and weaknesses of the existing Finnish reporting system and culture. In addition, recommendations will be given with regard to the reporting system and in an aim to improve aviation safety as regards bird strikes in Finland.

1.2 Methodology

The bird strike reports analysed were collected from the Finnish Transport Safety Agency's files for three separate years: 2000, 2006 and 2011. The number of reported bird strikes during the years 2001 - 2005 and 2007 - 2010 is also observed. This study is both quantitative and qualitative. Due to the difference in reporting activity for different years, more attention has been paid to the quality of the reports. All bird strikes involving Finnish-registered aircraft or reported at Finnish airports have been taken into account. The archivist kindly gave permission to use this data for research purposes in this thesis. The study was carried out in co-operation with the Finnish Transport Safety Agency.

1.3 Aims and Objectives

1.3.1 Aims

The aims of this thesis were to analyse the data of bird strikes reported in three different years in Finland, and to use this data to improve the Finnish bird strike reporting system and the flight safety in Finland. The analysis was carried out for three separate years (2000, 2006 and 2011), because the bird strike reports received in

different years were useful for showing any changes in the reporting culture as well as in the quality and quantity of the reports. The years between 2001 - 2005 and 2007 - 2010 are also taken into account by reviewing the number of bird strikes reported in each year.

1.3.2 Objectives

My specific research question was: *“What are the major differences in bird strike reports received by the Finnish Transport Safety Agency between the years 2000 and 2011?”*

The following data were collected from the bird strike reports received by the Finnish Transport Safety Agency in the years 2000, 2006 and 2011:

1. Type of the aircraft and engines.
2. Time and location.
3. Flight parameters / phase of flight.
4. Any damage to aircraft.
5. Effect on the flight.
6. Weather.
7. Bird species / size of bird.
8. How many birds were seen? / How many hit the aircraft?
9. Were pilots warned about the birds? / Heavy Bird Activity announcement.
10. Additional data

The years between 2001 - 2005 and 2007 - 2010 are also taken into account by reviewing the number of bird strikes reported in each year.

1.4 Chapter Structure

Chapter 1 is an introductory part, which gives the reader a general idea about the aims and objectives of this study and explains why it has been carried out.

Chapter 2 is a literature review, which briefly looks at some interesting general literature about collisions between birds and aircraft.

Chapter 3 shows the results of the research part in written form. Chapter 3 provides answers to all ten variables that were analysed in the bird strike reports received by the Finnish Transport Safety Agency in the years 2000, 2006 and 2011: 1. Type of the aircraft and engines, 2. Time and location, 3. Flight parameters / phase of flight, 4. Any damage to aircraft, 5. Effect on the flight, 6. Weather, 7. Bird species / size of bird, 8. How many birds were seen? / How many hit the aircraft?, 9. Were pilots warned about the birds? / Heavy Bird Activity announcement and 10. Additional data. The years between 2001 - 2005 and 2007 - 2010 are also taken into account by reviewing the number of bird strikes reported in each year.

Chapter 4 is the discussion part. The main findings are analysed here and compared with other similar studies at an international level.

Chapter 5 is the closing part. It contains the conclusions of this study and gives some ideas for future research.

Chapter 2: Literature Review

2.1 Introduction

This chapter briefly looks at some interesting general literature, which is available about collisions between birds and aircraft. When writing the words “bird strike” in Google, it gives over 24.000,000 hits. Due to the wide amount of different literature on the topic of bird strikes, this review is carefully limited in consideration of the aims and objectives and the problem statement of this study.

2.2 What are Bird Strikes?

2.2.1 Definitions of Bird Strike

A collision between an aircraft and a bird is called a bird strike. Synonyms for a bird strike are a bird hit and a Bird Aircraft Strike Hazard (BASH). Bird strikes are a common flight safety problem, and they will become an even more significant issue in the future as the number of aircraft and birds increases. Bird strikes are very frequent and may occur to all aeroplane categories.

There are several definitions for bird strikes. The main idea is the same, but slight differences can also be found. To give an example, SKYbrary has a definition stating that: “A bird strike is a collision between an airborne animal (most often a bird, but sometimes another species) and a man made vehicle, especially aircraft” (SKYbrary, 2012).

According to the International Bird Strike Committee (IBSC), bird /wildlife incidents are divided into three categories as follows:

“Confirmed strikes:

- Any reported collision between a bird or other wildlife and an aircraft for which evidence in the form of a carcass, remains or damage to the aircraft is found.
- Any bird/wildlife found dead on an airfield where there is no other obvious cause of death (e.g. struck by a car, flew into a window etc.).

Unconfirmed strikes:

- Any reported collision between a bird or other wildlife and an aircraft for which no physical evidence is found.

Serious incidents:

- Incidents where the presence of birds/wildlife on or around the airfield has any effect on a flight whether or not evidence of a strike can be found” (IBSC, 2006).”

To give one more example of bird strike definitions, Transport Canada has agreed with the Bird Strike Committee Canada (BSCC) to have their own criteria for ensuring harmonised reporting of bird strikes. According to that definition a bird strike has occurred, “if

- A pilot reports a bird strike;
- Aircraft maintenance personnel identify damage to an aircraft as having been caused by a bird strike;
- Personnel on the ground report seeing an aircraft strike one or more birds;
- Bird remains – whether in whole or in part – are found on an airside pavement area or within 200 feet of a runway, unless another reason for the bird’s death is identified.

Strikes against other classes of wildlife – primarily mammals – are interpreted with less formality, but embrace the spirit of definitions established for bird strikes.” (Transport Canada, 2004).

2.2.2 Bat Strikes

In some countries, strikes with bats are also categorised as bird strikes. Indeed, a strike with a bat can be very hazardous due to the bats’ habit of flying in large flocks and at night, when they are difficult to see. The bat’s anatomy brings some challenges as well, since bats do not have light and pneumatized bones like birds (Parsons et al., 2009). In Finland, however, bat strikes are not a flight safety issue.

2.3 Which Part of the Aircraft the Birds Normally Hit?

According to earlier studies by Transport Canada (2004), 15% of birds hit the aircraft nose. The wings and the engines both sustain about 13% of bird hits. The aircraft fuselage gets 11% of the bird strikes and the landing gear about 9%.

The European Aviation Safety Agency (EASA) has made research about accidents caused by bird strikes between the years 1999 and 2008. The engines sustained damage in 44% of the accidents. The wings were second with 31% and the windshield third with 13%. The nose part of the aircraft was damaged in only 8% of the strikes leading to an accident (EASA, 2009).

The latest study, made by Mr. John Thorpe, was presented in last IBSC meeting in Stavanger, Norway in June 2012. Thorpe’s study included bird strike data from last 100 years. According to this data, the aircraft engine was damaged in 76% of the accidents. Windshield damage led to an accident in 7% of the cases. Thorpe’s study focused on airliners and executive jets.

2.3.1 Which Part of the Aircraft is the Most Sensitive?

EASA (2009) has performed a similar study where they compared bird strike accidents between the years 1999 – 2008. This study pointed out the parts of the aircraft where the bird strikes had caused damage. The result was that the engines sustained some damage in 44% of the accidents. When the different engine types were examined more carefully, it could be concluded that turbofan engines sustained damage in 53% of the cases. The corresponding figure for turbo propeller engines was 38%, whereas reciprocating engines were damaged in only 6% and turboshaft engines in only 3% of the accidents. The wings suffered some damage in 31%, the windshield in 13%, the nose in 8% and the fuselage in 4% of the bird strike accidents (EASA, 2009).

2.4 Why are Bird Strikes Dangerous?

It is good to remember that most of the bird strikes do not cause any hazard. The probability of dying in a bird strike is very small. It is estimated that fatal bird strikes only occur once in a billion flying hours (Miller et al., 2010). It can also be misleading to think that strikes with large birds would always be the most dangerous ones. Even a flock of small birds can easily break an engine, windshield or another aircraft structure and lead to a serious hazard to safety. The size of the bird does not directly correlate with the damage sustained either. In fact, mass density varies a lot according to bird species. To give an example, a Laughing Gull (*Leucophaeus atricilla*) is about one third of the size of a Herring Gull (*Larus argentatus*), but has significantly higher density. Another interesting example is the Starling (*Sturnus vulgaris*). They have a 27% higher mass density than gulls and can form flocks with up to 100 000 birds. This is why Starlings are sometimes called “feathered bullets” (Transport Canada, 2004 and EASA, 2009).

Simply by following the laws of physics, the mass of the bird and the aircraft velocity are the two values that affect the kinetic energy of the strike. Of these two values, the

(squared) velocity actually has a stronger influence on the consequences than the bird's mass. Kinetic energy can be calculated using the formula:

$$\text{Kinetic Energy} = (\text{Mass} / 2) \times (\text{Velocity})^2$$

This makes a significant difference between the various phases of flight. During take-off, engines are often set at maximum power, while during approach, they can be running at idle. High engine RPM makes take-offs more dangerous than approaches if a bird strikes the engine.

2.5 Aircraft Certification

EASA has established detailed requirements for what an aircraft has to be able to endure when hitting a bird. Those requirements are shown in EASA certification CS-E800. According to the requirements, engines running at take-off thrust must be able to:

- Take a single large bird (1.85 – 3.65 kg) without any hazardous effect on the engine.
- Take flocking large birds (1.85 – 2.50 kg) without suffering no more than 50% loss of thrust and providing at least 20 minutes capability with some thrust variation.
- Take flocking medium sized birds (the mass of the birds can vary) losing a maximum of 75% of the thrust.
- Take small birds (mass 0.85 kg) losing a maximum of 25% of the thrust.

The airframe and, for example, the windshield have to be strong enough to sustain bird strikes as well. The certifications vary between different aircraft categories. To give an example, a normal passenger aircraft should be able to continue flying safely after hitting a bird of 1.80 kg at cruise speed (V_c). For some aircraft components, such as the empennage, which is an important part for aerodynamics and steering, this weight is doubled so that it must be able to sustain a bird strike of 3.60 kg. There are no specific requirements for fuel tanks (EASA, 2009).

2.6 History of Bird Strikes

Bird strikes became a safety problem as soon as people started to share the sky with birds. The first bird strike happened already in the year 1905, and the first fatality was caused seven years later in 1912. (LeMieux, 2009).

In 2009, EASA published estimations about the number of fatalities and hull losses caused by bird strikes. After the very first fatal bird strike in the year 1912, there have been 47 fatal bird strike accidents in commercial air transport operations, causing 242 fatalities and 90 hull losses. The actual figures are much higher, though, because military and general aviation are missing from EASA's report. The cost of bird strikes is over one billion Euros every year, and the value of any human life lost is priceless (EASA, 2009).

This study was recently updated by Mr. John Thorpe (2012) in the IBSC meeting in Stavanger. Thorpe's study shows that the number of fatal accidents caused by bird strikes has now risen to 55 and the number of fatalities to 276. Total hull losses have also increased to 108 (Thorpe, 2012).

A very recent example of a bird strike was the crash of a Sita Air Dornier Do 228 aircraft on 28th of September 2012 in Nepal. The aircraft was reported to have crashed shortly after taking off from Kathmandu airport. The pilot had told the air traffic controller that they had hit a vulture. The forced landing was unsuccessful, and all 16 passengers and 3 crewmembers died (BBC, 2012).

2.7 Bird Strikes – Growing Problem in the Future

Aviation is a rapidly growing business. During year 2011, a total of 2.8 billion passengers travelled by air using 38 million separate flights (IATA, 2012). The Airbus Company has recently published a Global Market Forecast (GMF) for the coming 20 years. The estimations in that forecast show a 4.7% annual increase in global passenger traffic. This means that 28,200 new transport or cargo category

aeroplanes would be needed and 10,350 old aircraft would have to be replaced by new modern aircraft. The total number of transport category aircraft is estimated to be over 32,550 by the year 2031, which is 110 % more than today. At the same time, the number of cargo category aircraft is estimated to increase from 1,600 to 3,000, which is almost the double. All this is going to cost approximately USD 4.0 trillion (Airbus, 2012).

But do we know how many birds there are sharing the sky with us? Globally, the number of individual birds has been estimated at around 100 billion. To give some examples, it is estimated that there are about 20 billion birds living in North America, about 180 million in the British Isles and about 64 million in Finland (Transport Canada, 2004).

By looking at the numbers above, there is no doubt that bird strikes are a significant safety issue now and in the future.

2.8 Altitudes Where Bird Strikes Happen

In commercial air transport, bird strikes usually take place during departures and approaches below 500 feet (Dolbeer, 2006). Many bird strikes also occur on the ground during take-off run or landing roll. According to Transport Canada research (2004), some 90% of all reported bird strikes where the phase of flight was given happened during take-off or landing. Normally the risk of bird strikes decreases when the altitude increases. However, there are always exceptions; some bird strikes have been reported even at flight level 370 (11,278 metres) (Layborne, 1974). During migration, birds have been reported to be seen even higher. To give an example, Bar-headed Geese (*Anser indicus*) have been seen above Mount Everest at 30,000 feet (9,144 metres) above sea level (ASL), and a flock of swans between Iceland and West Europe at 27,000 feet (8,229 metres) ASL. Mallards (*Anas platyrhynchos*) have been reported at 21,000 feet (6,400 metres) ASL and Snow Geese (*Chen caerulescens*) at 20,000 feet (6,096 metres) ASL. According to the observations, birds are normally

flying between 5,000 – 7,000 feet (1,524 – 2,134 metres) above ground level (AGL) during migration, but the altitude can vary from 1,600 feet up to 11,500 feet (488 – 3,505 metres) (Transport Canada, 2004). In conclusion, a bird strike can actually happen at any altitude.

The National Wildlife Strike Database for Civil Aviation in the United States received 38 961 reports of bird strikes between the years 1990–2004. Of those bird strikes, 26% (n = 10,143) occurred above the altitude of 500 feet (Dolbeer, 2006). Later a trend was found suggesting that the number of bird strikes above 500 feet was increasing. In Dolbeer's (2011) later study, it was revealed that the number of bird strikes occurring above 500 feet had actually increased from the year 1990 up to 30% between the years 2005 to 2009.

Bird strikes above 500 feet were most often caused by waterfowl, gulls, terns, passerines and vultures. Bird strikes below 500 feet most frequently involved passerines, gulls, terns, pigeons, doves and raptors.

The strikes causing damage to aircraft most often happened at altitudes over 500 feet (66%). Dolbeer (2011) also realised that the relative number of damaging bird strikes had increased from 37% in the 1990's up to 45% by the end of year 2009.

In the United States, bird strikes below 500 feet most often occur between July and October, when compared to the relative frequency of aircraft movements. Bird strikes are much more frequent during daytime than at night (Dolbeer, 2006). During autumn and spring migrations, however, some birds also fly actively at night time. It can be concluded that the risk of a bird strike is always present when you fly.

2.9 Climate Change and Bird Strikes

The bird population is increasing rapidly. During the past decade, some species that used to live in the south are now moving northward and bringing new challenges to the agriculture and fisheries, as well as safety problems to aviation. In Finland, the

new arrivals Barnacle Goose (*Branta leucopsis*) and Great Cormorant (*Phalacrocorax carbo*) are probably the best examples. The Great Cormorant (*Phalacrocorax carbo*) was nesting in Finland for the first time in 1996. Ten couples were counted at that time. By year 2009, the number of nesting couples had increased up to 16,000 couples. Another success story has been seen with the Barnacle Goose (*Branta leucopsis*). The first couple was nesting in Helsinki in 1989, and now the population is estimated to be between 3,000 – 5,000 couples only in the Helsinki area (Birdlife Finland, 2012).

In the United States alone, the goose population has grown from one million up to four million since 1990 (LeMieux, 2009). For example collisions with Canada Geese (*Branta Canadensis*), which are common in many places and are relatively large birds, have led to aircraft damage in about 67% of the strikes (Baxter and Robinson, 2007). A recent bird strike accident that attracted significant media attention in the USA was caused by a flock of Canada Geese. This accident happened on the 15th of January 2009 at 03:25 p.m. to US Airways flight 1549. The flight had just left LaGuardia Airport in New York when it hit the flock of birds. The accident caused the large transport category aircraft to ditch in the Hudson River in the centre of New York, but luckily everybody survived (LeMieux, 2009).

2.10 Understanding the Birds

To understand why bird strikes happen, we should know what the birds are thinking, what they see, how they react in different situations and why they are acting as they are. This is not a simple task at all, but it is exactly what we should learn by using the valuable data obtained from bird strike reports. Only by knowing the bird species and when, where and why they hit the aircraft, we can initiate effective preventive actions. It is not only by chance that the birds are acting like they do; they always have a reason for their different behavioural patterns. That is exactly what we have to learn so that, in the future, we could be one step ahead of the birds and share the sky safely with them.

A recent study shows, for instance, that we could reduce the risk of bird strikes by changing aircraft fuselage colours to brighter ones (Fernandez-Juricic et al., 2011). Everyone who has been flying and has seen another aircraft at the same altitude in the horizon can tell that a white aircraft can sometimes be extremely difficult to perceive even with human eyes.

The domain of sensory ecology investigates how the birds visualise their environment. This type of approach is useful when trying to understand why birds collide with aircraft.

One of the key issues is that the human perspective is not useful when trying to understand how birds visualise their environment, because the birds have a totally different visual world (Martin, 2011). To give an example, when birds want to look down they have to turn their heads in both pitch and yaw. This means that certain species are blind in the direction of travel when they are using their lateral vision to detect conspecifics and predators. This visualisation is ecologically more important for birds than looking straight ahead. Additionally, birds have only a limited range of flight speeds to adjust their rate of gain of visual information. In conclusion, this means that preventing bird collisions with aircraft is quite complicated and may be species specific (Martin, 2011).

2.11 How to Prevent Bird Strikes?

If there was an easy answer to this question, this study would never have been done. Since the International Bird Strike Committee (IBSC) was established in the year 1966, many different tools and practices have been developed for reducing bird strikes. Njå et al. (2012) were discussing the subject in the latest IBSC meeting in Stavanger, Norway. It can be concluded that there are so many variables involved in every single bird strike that the whole problem is extremely difficult, if not impossible to solve. Nevertheless, a significant part of the responsibility should rest with airport operators. They and their employees should be more aware of the local circumstances, since most bird strikes occur at aerodromes or in their vicinity. Wildlife management

should be a part of the aerodrome Safety Management Manual (SMM). Bird strike management at airports is also the subject of an MSc thesis written by Raulot (2009).

Continuous observation of birds and the airport environment helps to gain an idea on what species of birds appear in the local area and on their approximate numbers. Different seasons and bird migration need to be considered as well. After obtaining this knowledge, it is possible to start eliminating those factors that attract the birds to the airport.

Ideally, airports should be as uncomfortable for birds as possible. Very good results have been reached by simple reactive preventive actions, such as keeping the grass about 15 – 20 cm high. For example gulls and lapwings simply do not see the possible predators and other dangers around, and therefore do not feel safe and comfortable in that height of grass.

Food is another major factor that draws birds to airports. For example worms, insects, food remains or dead animals, water and agriculture can attract birds. When the grass is cut, birds often come looking for worms. For this reason, it is ideal to cut any grass areas at night when the birds are not active.

In addition, any nesting and resting places for birds should be destroyed immediately. Water areas should be filled up or changed so that they no longer attract birds. Small water basins can be covered with small plastic balls or nets. During migration, especially geese, cranes, swans and other waterfowl may land on large green areas such as airports for resting. There are a number of different tools and practices available for chasing away birds. The procedures vary from trained hawks, pyrotechnics, recorded bird warning shouts and laser pointers to eliminating some birds by shooting.

Ultimately, good and detailed reporting is an essential basis for any preventive action (Stenman and Joutsen, 2013).

2.11.1 Web-Based Bird Avoidance Systems

Knowledge about the density distribution and movement of birds is essential when we are seeking to reduce the number of strikes (Shamoun-Baranes et al., 2008). This data is needed both concerning times and three-dimensional space. Many authorities and volunteers are collecting this kind of data in different countries. Interestingly, Jonzén et al. (2006) have discovered a change in the spring migration of birds to Scandinavia. The authors found that especially long-distance migrants have been affected by the climate change and advanced their arrival to Scandinavia in spring. The authors call this finding a “climate-driven evolutionary change”. The study was based on long-term observational data from Scandinavia and Italy between 1980 and 2004.

Another study showed links between changes in agricultural practices and bird populations in Scotland (Benton et al., 2002). In this very long term follow-up study, it was found out that bird density was related to the measures of agriculture and climate. The study started about in 1970 and lasted for three decades. It was revealed that birds were more abundant during those years when there was less activity in agriculture. The authors believe that their results are applicable at least throughout the UK.

The above-mentioned studies are examples on how observational data may help to estimate bird density and distribution. However, it is not only observational studies that may help to collect data about bird density and distribution. Also radar ornithology is helpful in this task (Gauthreaux and Belser, 2003). In fact, radar ornithology has provided not only data related to the birds’ daily and seasonal movements, but also helped to understand how birds orient. With the help of these radars it is possible to compare migration patterns quantitatively and make comparisons between different seasons and years. Radars are used by military aviation in several countries, including the Netherlands, Germany, Belgium, Israel and the USA (Shamoun-Baranes et al., 2008). Radars may also be used to give real-time warnings.

Shamoun-Baranes and her co-workers (2008) used all the data described above, including observational studies and radar data, to create hazard maps and share that information through web services. This data could be used for flight planning and airfield management. The philosophy was to offer free data for all stakeholders using a freely available Internet platform. The authors wish that this type of culture will spread in the future and help to obtain data about the constantly changing bird populations.

2.12 History of Bird Strike Reporting in Finland

The Finnish Civil Aviation Authority started to collect information about bird strikes in the year 1978. One year later, on the 9th of January 1979, the Finnish Bird Strike Committee was established. The committee was composed of different aviation specialists. These specialists included members of airport management, air traffic controllers, fire and rescue workers, airport maintenance staff, experts from the Finnish Game and Fisheries Research Institute and experts from the Finnish Museum of Natural History.

Today the Finnish Bird Strike Committee continues its successful work and valuable mission in trying to prevent bird strikes. An important part of this mission is sharing knowledge with different operators, pilots and air traffic controllers in Finland. The committee holds its meetings twice a year, during the spring and autumn bird migrations. The core assembly has remained the same from the beginning. Today, however, all the main Finnish air operators, the Finnish Transport Safety Agency, the Finnish Meteorological Institute and the Finnish Military Aviation Authority are also represented in the Committee.

2.12.1 Bird Strike Reporting in Finland Today

Accident and incident reporting is well organised in Finland. The Finnish Transport Safety Agency receives over 5,000 occurrence reports annually, and the number of reports is increasing every year. The share of bird strike reports is about 4–5% of all reports. Provisions for reporting are contained in eight different laws and regulations, which govern reporting either directly or indirectly.

The basis for occurrence reporting is formed by the International Civil Aviation Organization (ICAO) Annex 13 (ICAO Annex 13, 2010) and the Finnish Aviation Act 1194/2009 (Finnish Aviation Act, 2009). These provisions are supplemented by European Commission Regulation No 859/2008 (EU-OPS) (European Commission, 2008) and Temporary Guidance Leaflet TGL 44, or for Helicopters, Joint Aviation Regulation JAR-OPS 3 (JAA, 2008). Other essential provisions are contained in Directive 2003/42/EC on occurrence reporting in civil aviation (European Commission, 2003), in Regulation No 996/2010 on the investigation and prevention of accidents and incidents in civil aviation (European Union, 2010), in the Finnish Safety Investigation Act 525/2011 (Safety Investigation Act, 2011) and in the Aviation Regulations GEN M1-4 (Finnish Aviation Regulation, 2011) and OPS M1-18 (Finnish Aviation Regulation, 2009).

The legislation on bird prevention at airports in Finland has remained the same since 22nd May 1997, when the Aviation Regulation AGA M3-13 (Prevention of birds and other wildlife at airports) entered into force. Aviation Regulation GEN M1-4 (Reporting of accidents, serious incidents and occurrences) that also regulates the reporting of bird strikes has been amended on 24th June 1999, 30th August 2006 and 1st April 2011. A major change was that in the amendment published in 1999, small bird remains (feathers) were instructed to be sent to the Civil Aviation Authority and larger remains (whole birds) directly to the Finnish Natural Museum for identification. The latest amendment of GEN M1-4 was published in 2011, and it does not contain separate provisions on bird strike reporting.

In Finland, the reporting of bird strikes is not mandatory, but it is strongly recommended by the aviation authority. Only if the aircraft sustains some damage or if the flight is affected by the bird strike, it is mandatory to file an incident report. This is required by Directive 2003/42/EC. Finnish airports are required to follow the national Aviation Regulation M3-13 (Finnish Aviation Regulation, 1997) in their wildlife management. This national aviation regulation is based on ICAO Annex 14 (ICAO Annex 14, 2004). All Finnish airports have to report any occurrences caused by wildlife to the Finnish Transport Safety Agency once a year. This annual report should include at least the number and species of animals eliminated and details about how the airport was seeking to prevent wildlife occurrences. In particular, the airport should report what actions were taken and which tools were used. Finnish airports are also required to compile a statistic summary based on occurrence reports filed in accordance with Regulation GEN M1-4 and maintain long-term statistics on bird strikes at the airport and in its vicinity.

2.12.2 What is Known about Bird Strikes in Finland?

The location of Finland and its rich, versatile nature provide an ideal environment for many different bird species. According to the calculations of Birdlife Finland, a total of 468 different species of wild birds had been seen in Finland by 4th of March 2012 (BirdLife Finland, 2012).

Birds are also a familiar issue in the aviation business and they are recognised as a potential flight safety problem. As mentioned earlier, the actual collection of bird strike data started in Finland in year 1978. During the past 36 years, however, many things have obviously changed. Not only that the aircraft are now bigger and faster and the number of operations and flight hours has been multiplied, but the bird population has changed as well. Many new arrival species are now nesting successfully in Finland, including for example the Barnacle Goose (*Branta leucopsis*) and the Great Cormorant (*Phalacrocorax carbo*).

Bird strikes are an interesting research subject. A lot of work has been done to prevent them, and the volume of bird strike reports is fairly good. For some reason, despite that, actual research or analysis on the subject has not been carried out earlier in Finland. The data collected is mostly used as material for statistics. Nevertheless, some trends are monitored and the Bird Strike Committee Finland goes through all the bird strike reports received twice a year. Bird strikes and their reporting has never been the subject of any academic research in Finland before.

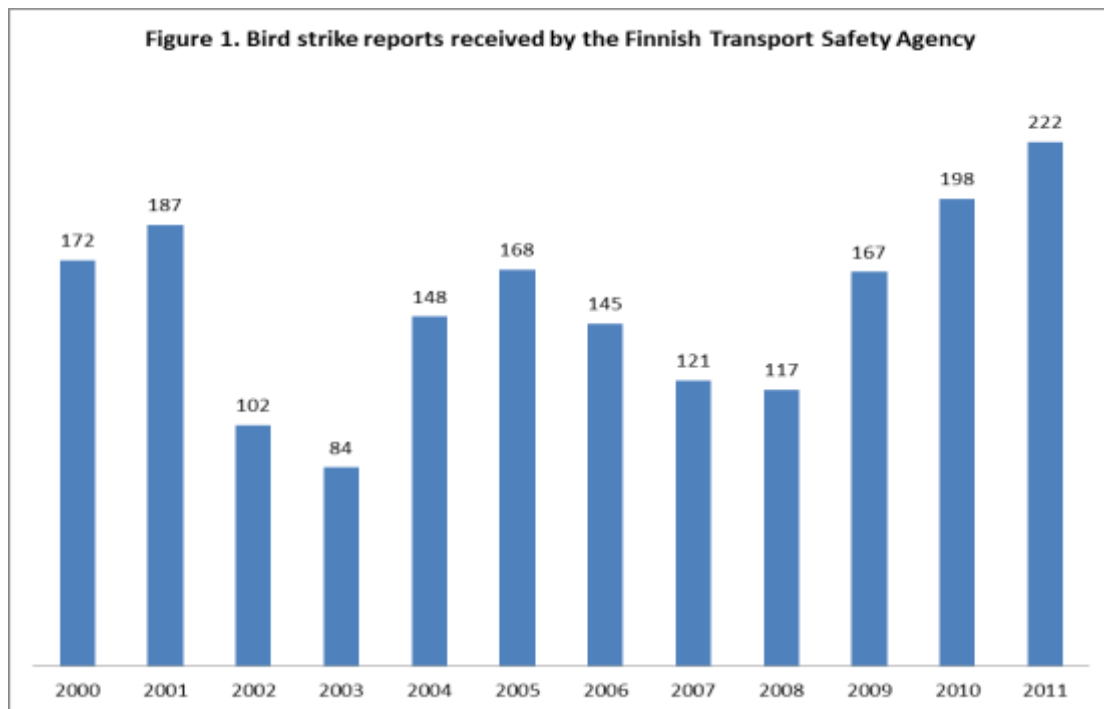
Chapter 3: Results

3.1 Introduction

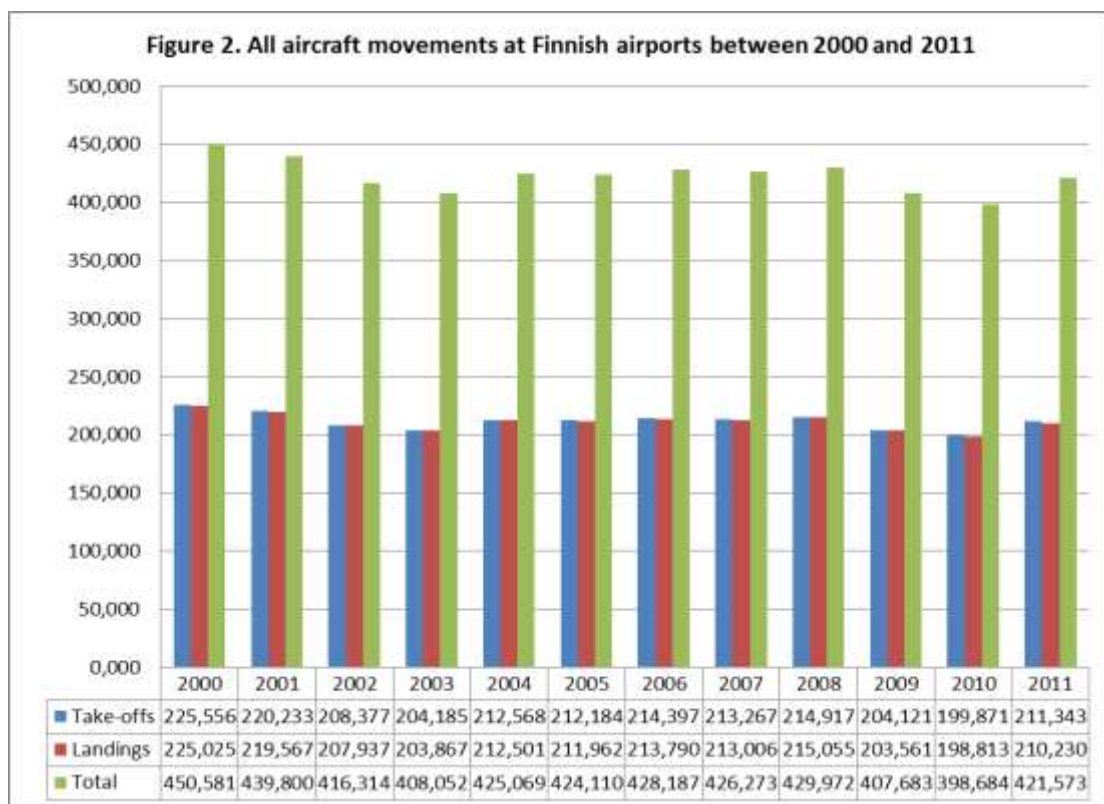
This chapter shows the results of the research in written form and in figures. It provides answers to all ten variables that were analysed in the bird strike reports received by the Finnish Transport Safety Agency in the years 2000, 2006 and 2011. The years between 2001 - 2005 and 2007 - 2010 are also taken into account by reviewing the number of bird strikes reported in each year.

3.2 Number of Bird Strike Reports Submitted

The data was collected retrospectively from bird strike reports submitted to the Finnish Transport Safety Agency between the years 2000 and 2011. The total number of bird strikes reported was 1,831. For each individual year, the numbers were 172 reports in year 2000, 187 reports in 2001, 102 reports in 2002, 84 reports in 2003, 148 reports in 2004, 168 reports in 2005, 145 reports in 2006, 121 reports in 2007, 117 reports in 2008, 167 reports in 2009, 198 reports in 2010 and 222 reports in 2011. In fact, the total number of reports was much higher because in some cases, not only the pilot but also an air traffic controller and/or airport maintenance staff submitted their own reports about the same bird strike. The number of reported bird strikes per year varies a lot during the period studied. This study makes an in-depth analysis of bird strikes reported in years 2000, 2006 and 2011 to better show the trends and changes that have occurred over the ten-year period. The development of the number of bird strikes reported to the Finnish Transport Safety Agency between the years 2000 and 2011 is also shown in Figure 1. All aircraft movements at Finnish airports between years 2000 and 2011 are shown in Figure 2 and Tables A1.1 and A1.2.



Source: 02.12.2013 / Finnish Transport Safety Agency



Source: 02.12.2013 / Finnish Transport Safety Agency

3.3 Types of Aircraft and Engines

Out of the total of 172 bird strikes reported in the year 2000, 115 (67%) happened to turbofan aircraft, 34 (20%) to turbo propeller aircraft, and 16 (9%) to aircraft with reciprocating engines. The remaining six (3%) strikes occurred to helicopters. Only in one report (1%), the aircraft type was unknown. These results are shown in Figure 3.1. In all, 30 different aircraft types were involved in bird strikes in the year 2000. Most of the strikes, 45 (26%), happened to DC9 aircraft. 17 (10%) strikes occurred to AT72 aircraft and 14 (8%) to MD83 aircraft. The exact division of bird strikes by aircraft type is shown in Tables A1.3 and A1.6.

Unfortunately, not all aircraft types have been followed in Finavia Corporation's statistics on aircraft movements at Finnish airports. For example, data on movements by DC9 aircraft, which caused the largest number of bird strike reports in the year 2000, were missing. AT72, which had the second largest share of the reports, had a total of 53,671 take-offs and landings in Finland and 17 reported bird strikes. This gives a probability of 0.03% for bird strikes when operating with AT72. Details on MD83 aircraft movements were also missing.

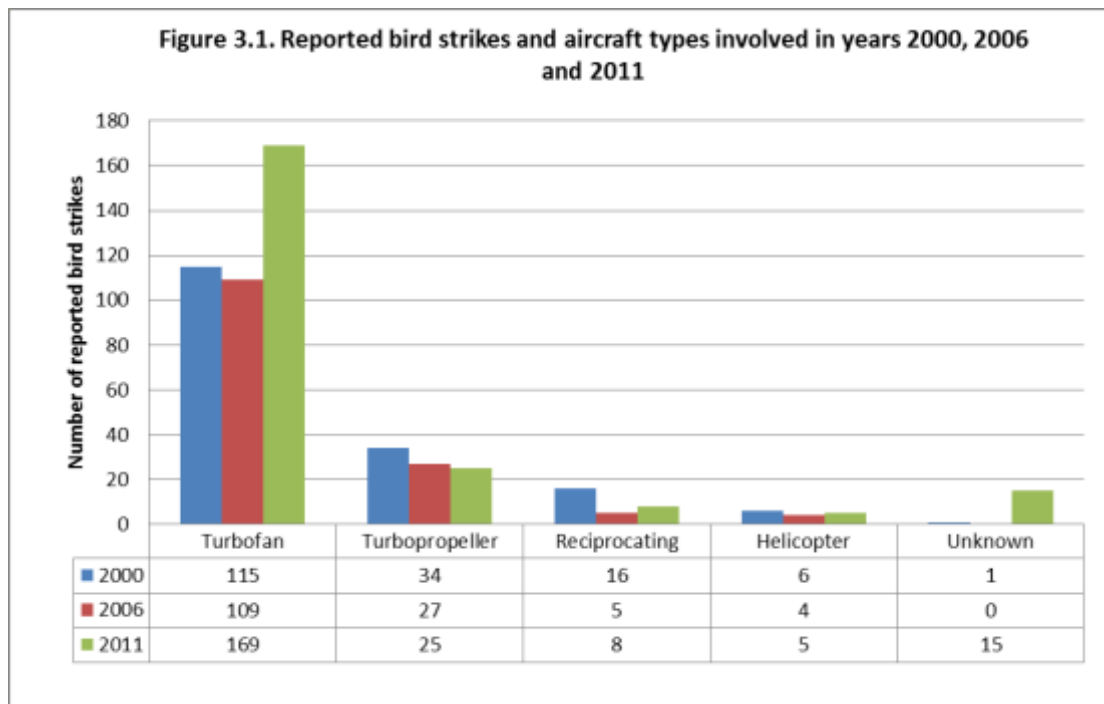
In the year 2006, the total number of bird strikes was 145. Of them 109 (75%) happened to turbofan aircraft, 27 (19%) to turbo propeller aircraft, 5 (3%) to aircraft with reciprocating engines and 4 (3%) to helicopters. The type of aircraft and engine was identified in every report. These results are shown in Figure 3. A total of 36 different aircraft types were involved in bird strikes in year 2006. Most of the strikes, 16 (11%), occurred to A320 aircraft. The second was B757 with 14 (10%) bird strike reports and the third AT72 with 11 (8%) reports. All aircraft types involved in bird strikes in the year 2006 are shown in Tables A1.4 and A1.6.

A320 aircraft had a total of 68,334 take-offs and landings in Finland in the year 2006. This gives a probability of 0.02% for a bird strike. B757 aircraft had 9,371 take-offs and landings in Finland, which corresponds to a bird strike probability of over 0.1%. AT72 aircraft took off and landed in Finland for 34,972 times, with a probability of 0.03% for a bird strike.

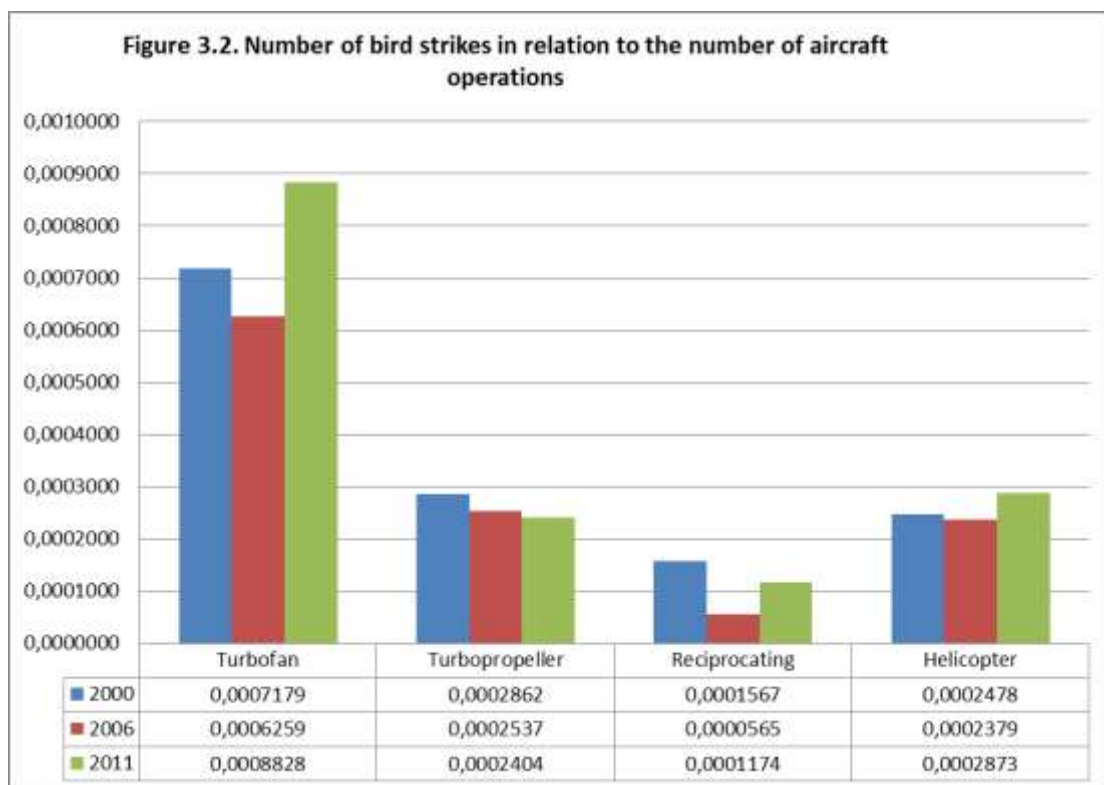
Out of the 222 bird strikes in 2011, 169 (76%) happened to turbofan aircraft, 25 (11%) to turbo propeller aircraft, 8 (4%) to reciprocating-engine aircraft and the remaining five (2%) to helicopters. In 2011, the aircraft type was not given or was unknown in 15 reports (7%). These results are also shown in Figure 3. Bird strikes were reported for 32 different aircraft types. Most of them, 30 (14%), happened to the type ERJ-190. A320 aircraft were involved in 26 reports (12%). Third place was shared between A319 and B757, which were both involved in 25 (11%) of the bird strikes reported in year 2011. The exact distribution of bird strikes by aircraft type in year 2011 is shown in Tables A1.5 and A1.6.

For ERJ-190 aircraft, the probability to hit a bird was over 0.1% out of 24,470 take-offs and landings. A320 aircraft took off and landed for 65,928 times during year 2011, which gives a probability of 0.04% for a bird strike. Third place was shared by the aircraft types A319 and B757. The movements of A319 aircraft were not separated in Finavia Corporation's data. B757 aircraft had 7,316 take-offs and landings, which means a bird strike probability of over 0.3%.

Figure 3.2. shows the probability of bird strikes by aircraft category (number of bird strikes divided by the number of aircraft movements). It is interesting to see that helicopters have a surprisingly high probability of hitting a bird. The results are about the same as for turbopropeller aircraft, and in the year 2011, the figure for helicopters was even higher.



Source: 02.12.2013 / Finnish Transport Safety Agency



Source: 02.12.2013 / Finnish Transport Safety Agency

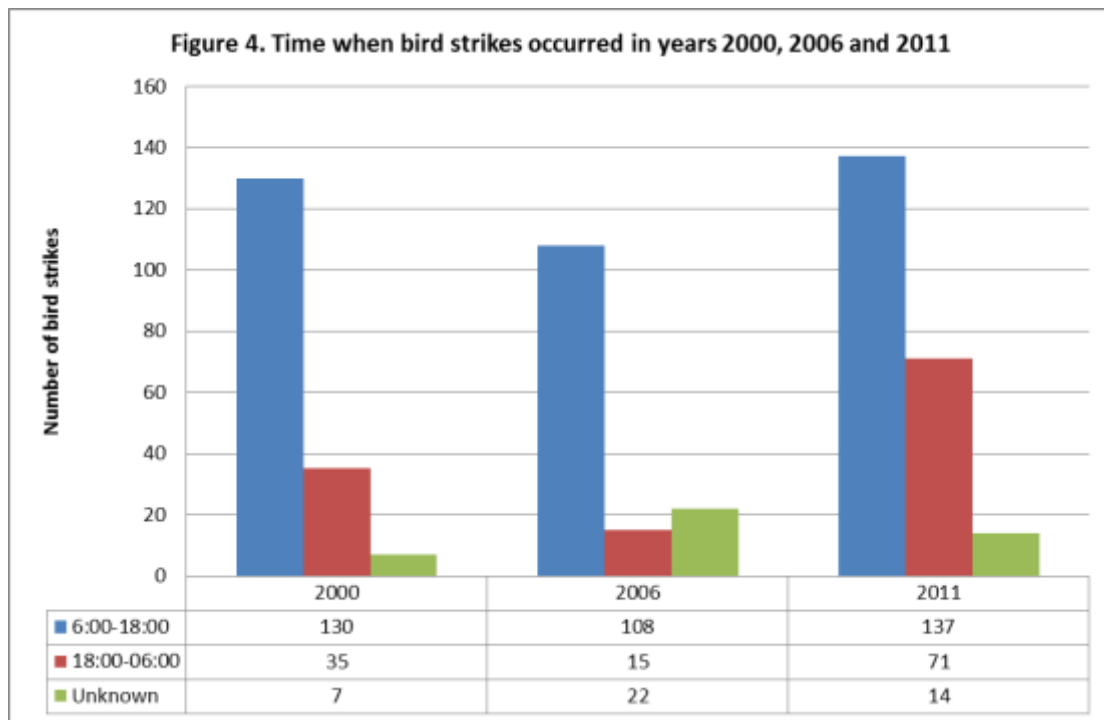
3.4 Time of Day When the Bird Strikes Occurred

In the year 2000, 130 bird strikes (76%) out of the total of 172 occurred in daytime between 06:00 – 18:00 local time LT, while 35 (20%) occurred in the evening or at night between 18:00 – 06:00 LT. In seven reports (4%), the time of day was not given or was unknown. The results are shown in Figure 4.

Out of the total of 145 bird strike reports received in the year 2006, 108 (74%) occurred in daytime between 06:00 – 08:00 LT. 15 (10%) occurred in the evening or at night between 18:00 – 06:00 LT. The time was not given or it was unknown in 22 (15%) reports. The results are shown in Figure 4.

In the year 2011, 137 bird strikes (62%) out of the total of 222 occurred in daytime between 06:00 – 18:00 LT, and 71 (32%) occurred in the evening or at night between 18:00 – 06:00 LT. In 14 reports (6%), the time was not given or was unknown. The results are shown in Figure 4.

Unfortunately, time data for aircraft movements is missing. The number of take-offs and landings is significantly higher between 06:00 – 18:00 than between 18:00 – 06:00. Figure 4 therefore shows only the number of bird strikes, not the probability.



Source: 02.12.2013 / Finnish Transport Safety Agency

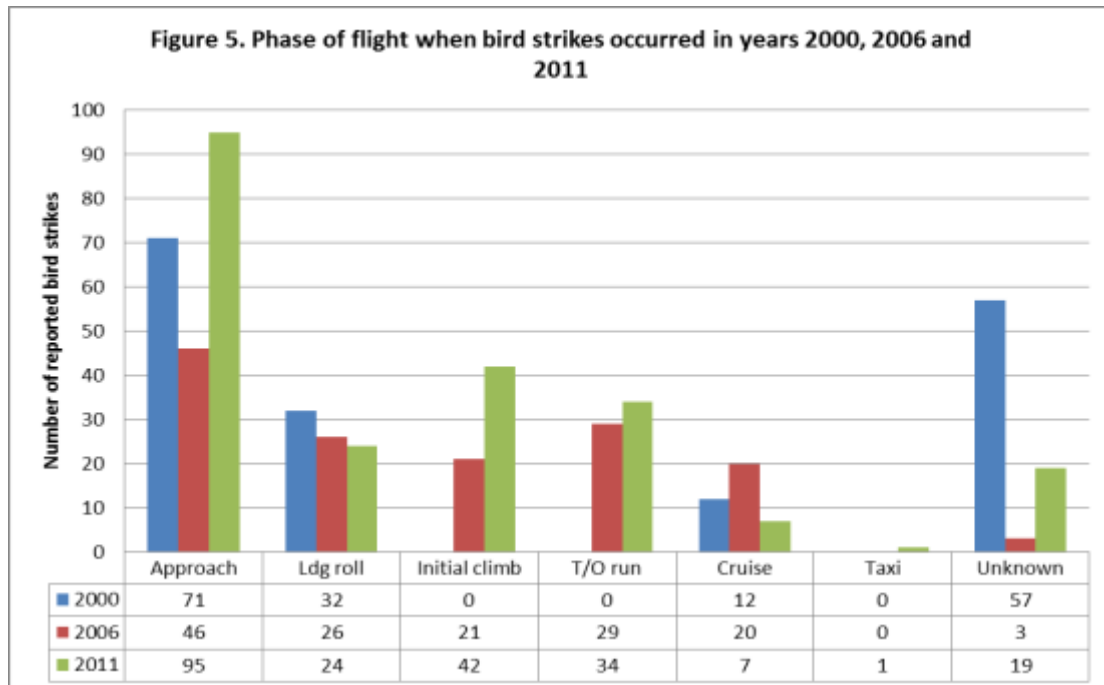
3.5 Phase of Flight When the Bird Strikes Occurred

Out of the 172 bird strikes reported in the year 2000, 71 (41%) occurred during approach, 32 (19%) during landing roll and 12 (7%) during cruise flight. In 57 reports (33%), the phase of flight was not given or was unknown, or the bird strike was only detected after the aircraft had been parked. (Figure 5).

In the year 2006, the total number of bird strikes was 145. Of them 46 (32%) took place during approach, 26 (18%) during landing roll, 21 (14%) during initial climb, 29 (20%) during take-off run and 20 (14%) during cruise. Only in 3 (2%) of the reports, the phase of flight was marked as unknown. (Figure 5).

Of the total of 222 bird strikes reported in 2011, 95 (43%) occurred during approach, 24 (11%) during landing roll and 42 (19%) during take-off or initial climb (Figure 5). Of the remaining bird strikes, 34 (15%) occurred during take-off run and 7 (3%) during cruise flight, and one bird strike was reported to have happened during the taxi

phase. In 19 of the reports (9%), the phase of flight was not given or was unknown, or the bird strike had been detected only after the aircraft was parked.



Source: 02.12.2013 / Finnish Transport Safety Agency

3.6 Damage to Aircraft and Effect on the Flight

In the year 2000, out of the total of 172 bird strikes, 12 (7%) were reported to have caused some damage to the aircraft. In six (50%) of the cases where some damage was reported, it was so significant that it had influenced the flight and forced it either to land as soon as possible or to return to the airport of departure. In five (40%) of the cases the damage was minor and had no effect on the flight. In one case (10%) some damage was reported, but it was not stated whether it had an effect on the flight or not. In all, 160 (93%) of the bird strikes reported did not cause any damage to the aircraft.

Of the total of 145 bird strikes reported in 2006, some damage was mentioned in eight (6%) cases. There were no reports about any effects on the flight, such as an

immediate landing or returning back to the departure airport. 137 (94%) of the bird strikes reported did not cause any damage to the aircraft.

In the year 2011, some damage was reported in 11 (5%) of the 222 bird strikes. In all of these reports, the bird strike had some influence on the flight. In eight (4%) cases the bird strike had no effect on the flight. There are some inaccuracies in the reported figures, because there were only 11 reports that informed about some damage, but in 19 reports it was stated that the bird strike had caused some effect on the flight. A total of 211 (95%) of the bird strike reports stated that there was no damage to the aircraft.

Among the bird strikes analysed only one was fatal. This was a glider accident which happened in Spain in 2011. In this accident, a Finnish glider was hit by a Griffon Vulture (*Gyps fulvus*), weighing approximately 10 kg. The glider's fin was so badly damaged that the pilot lost control of the glider, which crashed into the ground causing the loss of two lives. The accident is currently under investigation by the Spanish Accident Investigation Board.

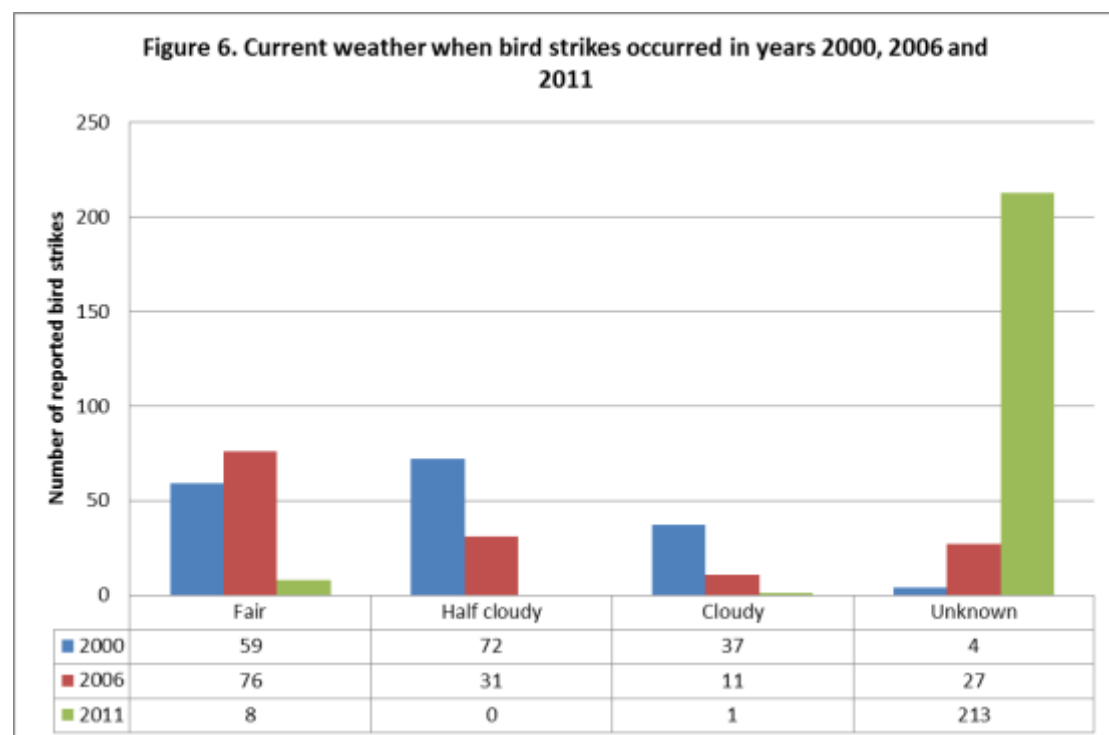
3.7 Weather

Weather details were indicated very well in the reports for year 2000. Out of the total of 172 bird strikes, 59 (34%) occurred in good weather when the sky was clear, 72 (42%) when the sky was partly cloudy and 37 (22%) when the sky was overcast. Only in the remaining four cases (2%) the weather was unknown or the weather information was not given. It is also possible to report other weather related observations on the form. Altogether 14 forms reported this additional information. Six (3%) of the reports mentioned fog and 8 (5%) reported light rain showers. (Figure 6).

Out of the total of 145 bird strike reports received in the year 2006, weather details were missing or not known in 27 (19%). Most of the bird strikes, 76 (52%), took place in fair weather with no clouds. In 31 (21%) of the cases, the weather was partly

cloudy and in 11 cases (8%) the weather was reported to be cloudy. (Figure 6).

In the year 2011, weather details were missing from most of the reports. In as many as 213 reports (96%), the weather information was not given or had been marked as unknown. Only 8 reports (4%) mentioned that the sky was clear and one stated that the sky was overcast. No bird strikes were reported to have happened when the sky was partly cloudy. Any other weather related observations were also poorly reported. Only one report mentioned that there had been some rain showers. (Figure 6).



Source: 02.12.2013 / Finnish Transport Safety Agency

3.8 Bird Size and Identification of Species

Out of the total of 172 bird strikes reported in the year 2000, in 112 (65%) the birds hitting the aircraft were small, in 53 (31%) they were medium size, and only one case involved a large bird (Figures 7 and 8). In four cases (2%), the size of the bird was not given or not known. Altogether, an exact determination of the species was made in 53

(30%) of the cases. Out of the 112 small birds, 28 (25%) were identified, and out of the 53 medium-size birds, 24 (45%) were identified. The only large bird that hit an aircraft was identified as an Eagle Owl (*Bubo bubo*).

In the year 2006, 77 (53%) out of the 145 reported bird strikes happened with small birds. 52 (36%) of the strikes were with medium-size birds and in 4 cases (3%), the bird size was marked to be large. In 12 (8%) of the occurrences the size of bird was unknown or not marked. An exact determination of species was made in 18 (12%) of the cases. Out of the 77 small birds, only 6 (8%) were determined by species. For medium-size birds an exact determination was made 10 times (19%) out of the total of 52 cases. None of the four large birds was determined by species. One was marked to be a swan, but the exact species was not known. (Figures 7 and 8).

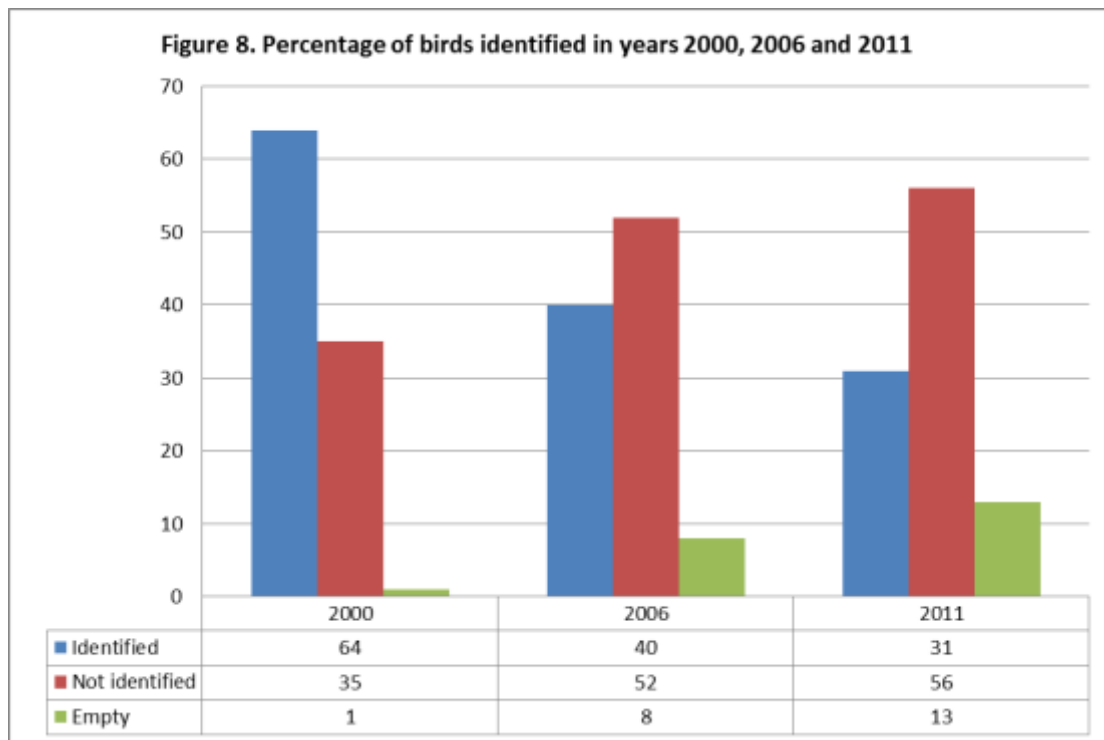
Out of the 222 bird strikes in 2011, 121 (55%) involved small birds and 68 (30%) medium-size birds. There were no strikes with large birds except for the glider accident in Spain, which resulted from a strike with a vulture. However, this accident has not been reported as a bird strike to the Finnish Transport Safety Agency. In 33 cases (15%), the size of the bird was not given or not known (Figures 7 and 8). An exact determination of the species was made only in 22 (10%) of the cases. Out of the 121 small birds, only 6 (5%) were identified, and out of the 68 medium-size birds, 16 (24%) were identified.



Source: 02.12.2013 / Finnish Transport Safety Agency

In the years, 2000, 2006 and 2011, strikes with small birds were most commonly reported. On the other hand, small birds were the least often identified. For example, passerines, swallows and thrushes were usually not precisely identified by species. The best-identified small bird in the year 2000 was the Snow Bunting (*Plectrophenax nivalis*), in the year 2006 Starling (*Sturnus vulgaris*) and Wagtail (*Motacilla alba*) and in the year 2011, it was the Skylark (*Alauda arvensis*).

Medium-size birds were identified better in all studied years. Especially grouses and different types of waterfowl were very well identified by species. Problems with identification were most often encountered with gulls and predators. Large birds were generally easier to identify. Also if the bird has a prominent appearance, such as the Lapwing (*Vanellus vanellus*), Black Grouse (*Lyrurus tetrix*) or Eagle Owl (*Bubo bubo*), it was frequently identified. Year 2006 showed that not all large birds are determined correctly by species. For example the two swan species living in Finland, the Whooper Swan (*Cygnus cygnus*) and Mute Swan (*Cygnus olor*), were not identified in bird strike reports.



Source: 02.12.2013 / Finnish Transport Safety Agency

3.9 Number of Birds Seen and Number of Birds that Hit the Aircraft

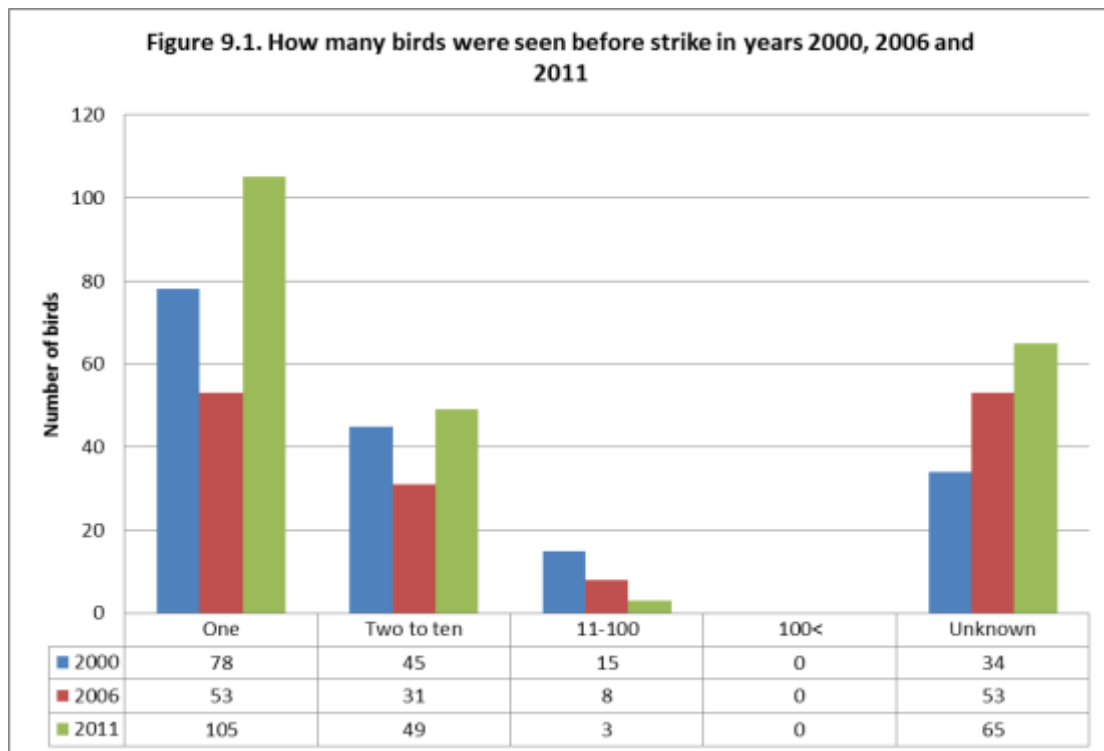
Of the 172 bird strikes reported in 2000, only one bird was seen before the strike in 78 cases (45%). Respectively, it was reported that one bird hit the aircraft in 146 (85%) of the cases. Two to ten birds were seen in 45 (26%) cases before the strike, but only in 15 (9%) the reported number of birds actually hit the aircraft. In 15 cases (9%) a flock of 11 – 100 birds was seen, but there were no strikes reported with these large flocks of birds. The field “How many birds were seen” was left empty in 34 (20%) cases, and the field “how many birds hit the A/C “ was left empty in 11 (6%) cases (Figures 9.1, 9.2. and 10).

Out of the total of 145 bird strikes reported in the year 2006, one bird was seen before the strike in 53 cases (37%). One bird actually hit the aircraft in 110 (76%) of the strikes. Two to ten birds were seen in 31 (21%) cases, but two to ten birds actually hit the aircraft only 16 (11%) times. Flocks of 11 to 100 birds were seen eight times, but

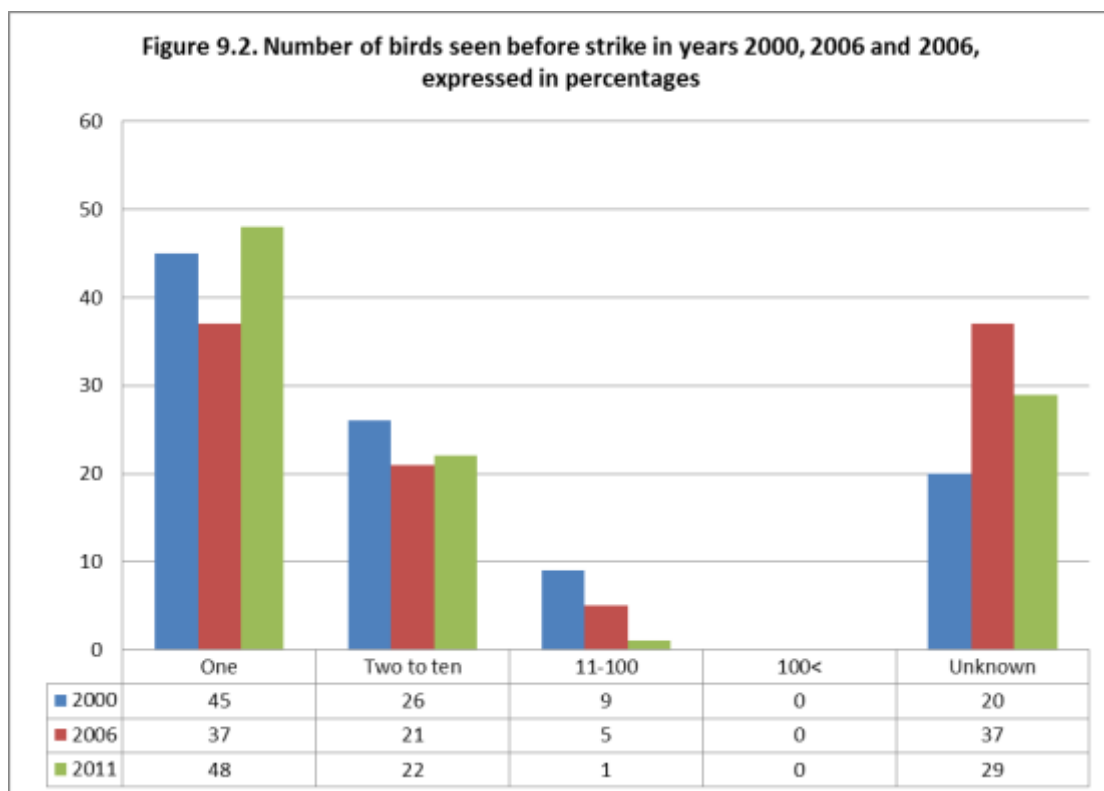
flocks of that size never hit the aircraft. Flocks of over 100 birds were either not seen or were not reported to hit the aircraft. How many birds were seen was reported as unknown or the field was left empty in 53 reports (37%). How many actually hit the aircraft was unknown or not marked in 19 (13%) of the cases. (Figures 9.1, 9.2. and 10).

Of the total of 222 bird strikes reported in 2011, only one bird was seen in 105 cases (47%) and one bird hit the aircraft in 141 (64%) of the cases. Two to ten birds were seen in 49 (22%) cases and two to ten birds actually hit the aircraft in 19 (9%) of the cases. A flock of 11 – 100 birds was seen three times, but strikes with large bird flocks could be avoided. The field “How many birds were seen” was left empty in 65 (29%) cases and the field “how many birds hit the A/C” was left empty in 62 (28%) cases (Figures 9.1, 9.2. and 10).

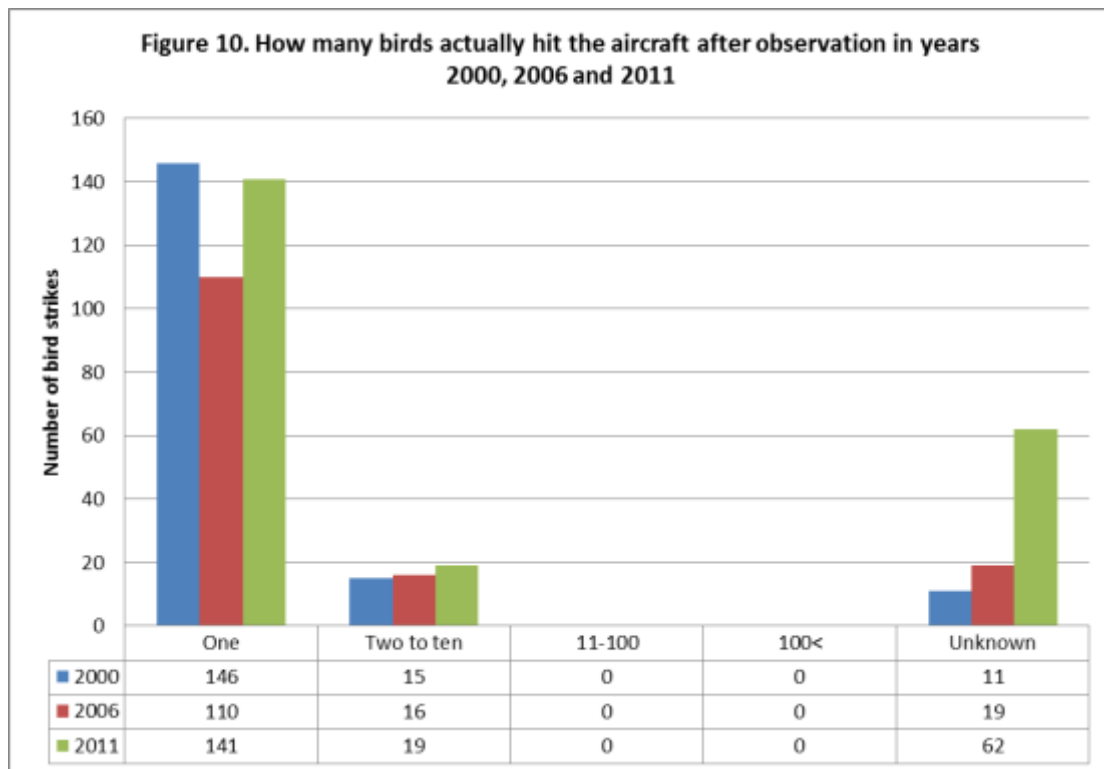
Every year, most of the bird strikes were caused by single birds. The number of strikes correlates with the number of birds seen before the strike. Single birds are causing a large number of strikes because they are often difficult to see before it is too late. Pilots, air traffic controllers and maintenance staff react better if flocks of birds have been seen at the airport or in its vicinity. A small single bird is not perceived as a real threat.



Source: 02.12.2013 / Finnish Transport Safety Agency



Source: 02.12.2013 / Finnish Transport Safety Agency



Source: 02.12.2013 / Finnish Transport Safety Agency

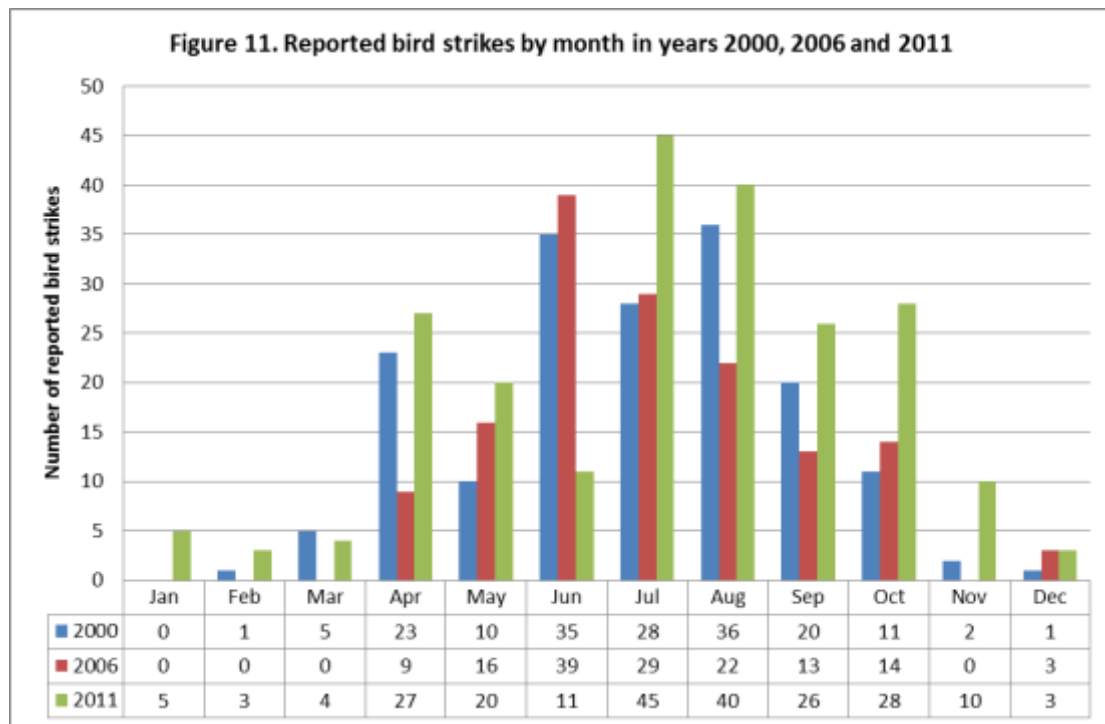
3.10 Time of Year When the Bird Strikes Occurred

In the year 2000, out of the total of 172 bird strikes reported, only 2 (1%) happened during winter (December to February), 38 (22%) in spring (March to May), 99 (58%) in summer (June to August) and 33 (19%) in autumn (September to November) (Figure 11).

In the year 2006, out of the total of 145 bird strikes reported, only 3 (2%) happened during winter (December to February), 25 (17%) in spring (March to May), 90 (62%) in summer (June to August) and 27 (19%) in autumn (September to November) (Figure 11).

In the year 2011, out of the total of 222 bird strikes reported, 11 (5%) happened during winter (December to February), 51 (23%) in spring (March to May), 96 (43%) in summer (June to August) and 64 (29%) in autumn (September to November)

(Figure 11).



Source: 02.12.2013 / Finnish Transport Safety Agency

As expected, all three years 2000, 2006 and 2011 were fairly similar when comparing the relative frequency of bird strikes in different seasons. Winter is always quiet, as the large airfields are covered by snow and have nothing to offer for the birds. Spring and summer are different; airfields then become ideal places for many birds for nesting and searching for food. This correlates strongly with the increasing number of bird strikes. In the early summer, some adult birds are flying a lot to find food for their offspring, and later in the summer, young birds are not sufficiently skilled in flying and in looking out for the dangers on the airfield.

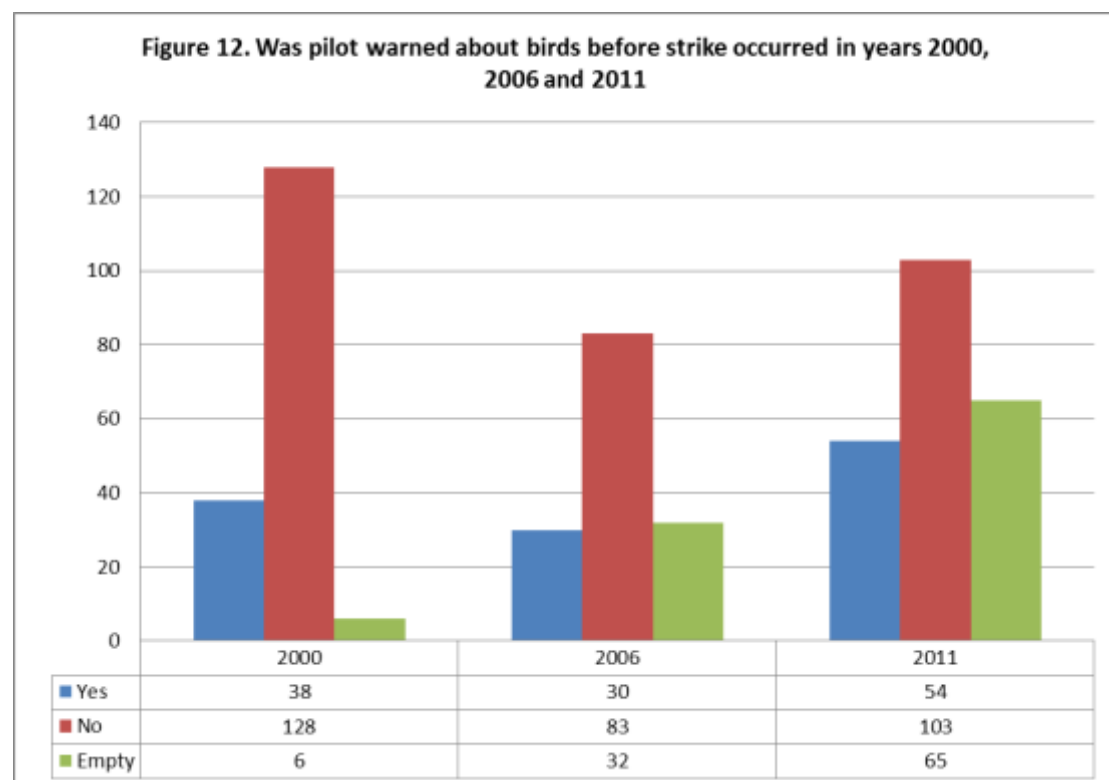
The higher number of birds in summer can also be noticed when looking at the numbers of aircraft operations. For example in year 2011, the quietest month at Finnish airports was July with 9,648 landings.

3.11 Were Pilots Warned about the Birds?

When looking at the 172 bird strikes reported in 2000, the pilot was warned about birds in the vicinity of the aerodrome in 38 (22%) cases. No warnings were given in 128 (75%) cases and no answer to this question was available in six (3%) of the cases. (Figure 12).

Out of the total of 145 bird strikes reported in 2006, pilots were warned in 30 cases (21%). In 83 (57%) cases, the pilots were not warned at all about possible heavy bird activity. In 32 (22%) reports this question was not answered. (Figure 12).

Out of the total of 222 bird strikes reported in 2011, the pilot was warned about possible bird activity in 54 (24%) cases, a heavy bird activity warning by Automated Terminal Information Service (ATIS) was reported in only 4 (2%) cases and no warnings were given in 103 (46%) cases. In 65 (29%) cases the question was not answered or it was left empty. (Figure 12).



Source: 02.12.2013 / Finnish Transport Safety Agency

3.12 Airports Where the Bird Strikes Occurred

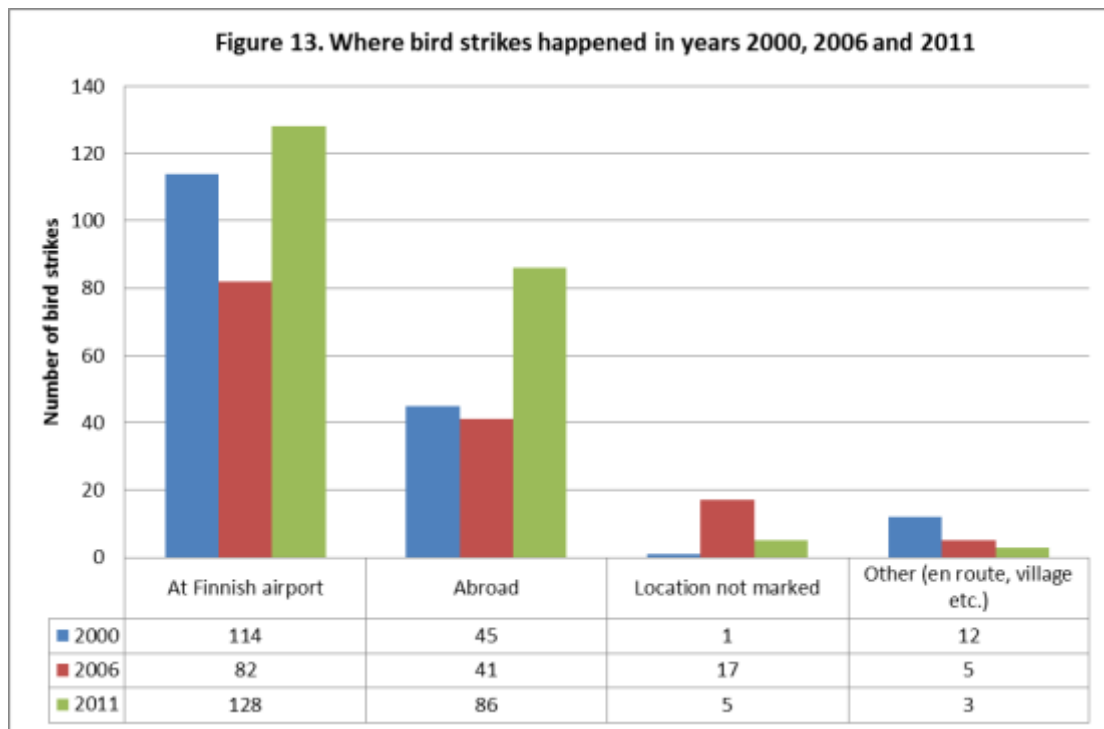
How bird strikes reported in the years 2000, 2006 and 2011 were divided between Finnish airports, locations abroad, other places (en route, area, village or town) and cases where the location was not marked is shown in Figure 13.

In the years 2000, 2006 and 2011, bird strikes were reported from 26 different airports in Finland. The Finnish airports and numbers of bird strikes reported there are shown in Figure 14.

In the year 2000, out of the total of 172 bird strikes, 114 (66%) occurred at Finnish airports. 45 (26%) of the strikes took place outside Finland. Only in one case (1%) the location was marked as unknown. In 12 (7%) of the reports, the place of occurrence was en route or the name of an area or village was mentioned.

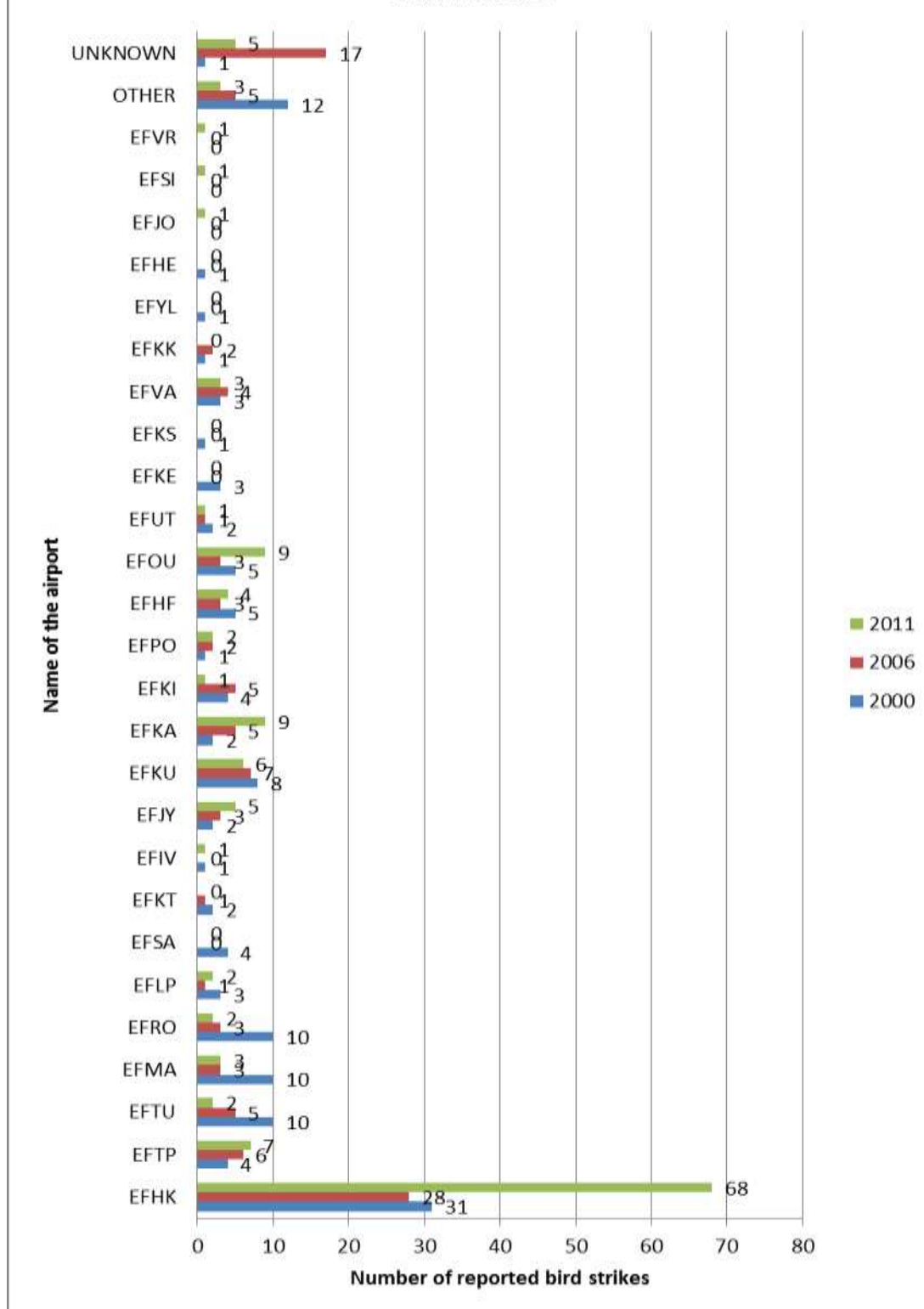
In the year 2006, out of the total of 145 bird strikes, 82 (57%) happened at Finnish airports. 41 (28%) strikes were reported to have occurred outside Finland. In 17 (12%) reports, the exact place of occurrence was not given, and in 5 cases (3%) the location was marked as en route or a village or town was named.

In the year 2011, out of the total of 222 bird strikes, 128 (58%) were reported from Finnish airports. In 86 (39%) reports, the place of occurrence was marked to be outside Finland. In 5 cases (2%) the location was not marked, and in 3 cases (1%), the place was marked as en route or the name of an area or village was given.



Source: 02.12.2013 / Finnish Transport Safety Agency

Figure 14. Airports where bird strikes occurred in years 2000, 2006 and 2011



Source: 02.12.2013 / Finnish Transport Safety Agency

Helsinki-Vantaa International Airport (EFHK) has been the best-reporting airport in Finland every year. All wildlife activities are monitored at EFHK by Finavia Corporation. The airport area is parcelled out into small lots (Table A1.10), and any movements, observations, dispersals and eliminations of birds and mammals are marked down on airport maps. A sample of wildlife management actions in the spring, summer and autumn of 2010 is shown in Tables A1.11 and A1.12.

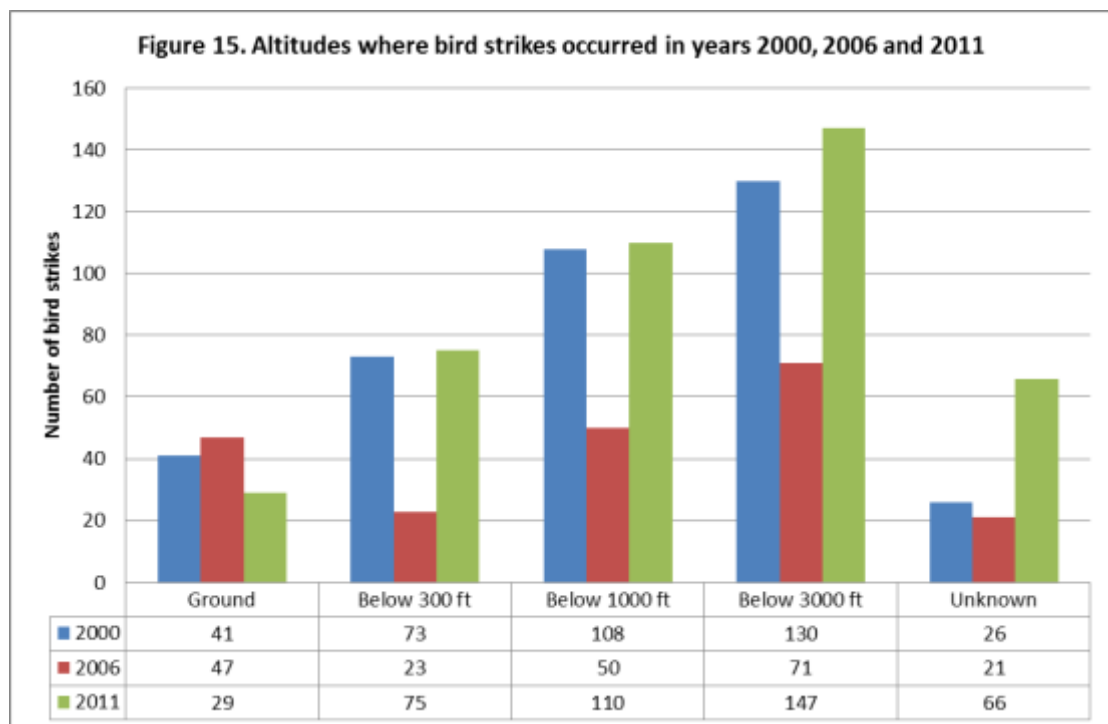
The EFHK airport area covers a total of 1700 hectares, and it is surrounded by forest and fields. Between the parallel runways 04-22L and 04-22R is a boggy area that provides an ideal environment for many birds and mammals. Also the vicinity of the Baltic Sea brings challenges, as the airport has to tackle with a rapidly growing population of Barnacle Geese (*Branta leucopsis*).

3.13 Altitudes (QNH) Where the Bird Strikes Occurred

In 2000, 41 (24%) out of the total of 172 reported bird strikes happened on the ground. Of the bird strikes in the air, 73 (42%) occurred below 300 feet, 108 (63%) below 1000 feet and 130 (76%) below 3000 feet. Only 8 (5%) bird strikes occurred above 3000 feet, and in 26 (15%) of the cases the altitude was not known or not given. The maximum altitude where bird strikes occurred was 7000 feet, with two reported strikes. The altitudes are shown more precisely case-by-case in Figure 15.

In the year 2006, 47 (32%) out of the total of 145 bird strikes reported took place on the ground. 23 (16%) bird strikes happened below the altitude of 300 feet, 50 (34%) below 1000 feet and 71 (49%) below 3000 feet. In 21 (14%) reports the altitude was not known or not marked. A few individual bird strikes occurred at higher altitudes: two at 4000 feet, one at 7000 feet, one at 7500 feet, one at 8000 feet and one at 11000 feet. The bird strike at 11000 feet was marked as having been caused by a large bird and resulted in wing trailing edge damage to an Airbus A320. (Figure 15).

Of the total of 222 bird strikes reported in 2011, 29 (13%) happened on the ground. Of those that occurred in the air, 75 (34%) took place below the altitude of 300 feet, 110 (49%) below 1000 feet and 147 (66%) below 3000 feet. Nine (4%) of the bird strikes were reported to have happened above 3000 feet altitude, and in 66 (30%) of the reports the altitude was not known or not given. The maximum altitude reported was 5000 feet, where two strikes occurred (Figure 15).



Source: 02.12.2013 / Finnish Transport Safety Agency

Chapter 4: Discussion

4.1 Introduction

In this chapter the main findings are analysed and compared with other international findings.

4.2 Reporting of Bird Strikes

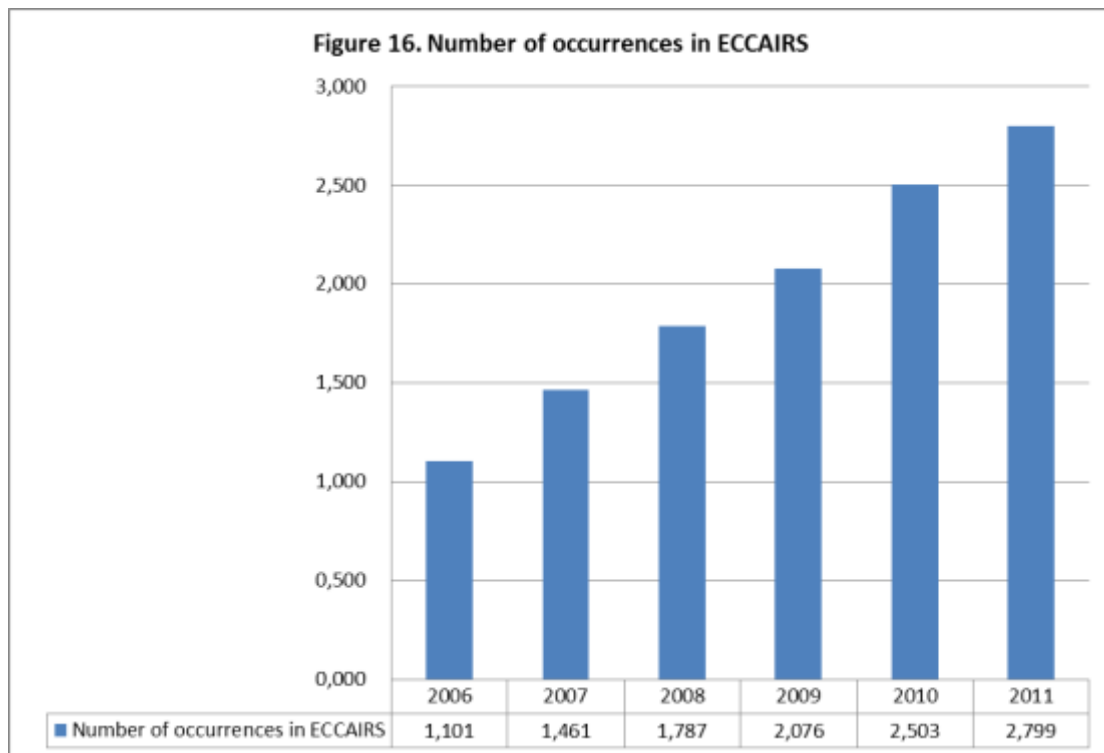
This study shows that the number of bird strike reports in Finland has significantly increased from the year 2000 to the year 2011. At the same time, however, aircraft movements at Finnish airports have decreased. In the year 2000, the number of landings was 225,025, while the corresponding figure for 2011 was 210,230 landings (Table 3). In conclusion, there were altogether 14,795 (7%) less landings but 50 (23%) more bird strike reports in the year 2011 than in 2000. The year 2011 thus showed a clear improvement in bird strike reporting compared to the year 2000.

The years between 2000 and 2011 were all very different. One of the best-reported years was 2001, when the former Finnish Civil Aviation Authority received 187 bird strike reports. In the year 2003, the reporting activity dropped to only 84 reports. Since the year 2007, the number of bird strike reports has been increasing every year, including the year 2012.

The Finnish Civil Aviation Authority started to use the ECCAIRS (European Coordination Centre for Accident and Incident Reporting Systems) on 1 July 2005. This database shows that the number of all types of occurrence reports has been increasing significantly during the last few years in Finland. At the same time, aircraft movements have remained the same or even decreased during the years 2009 and 2010.

In conclusion, the actual number of bird strikes has not increased, but occurrence

reporting in general has been growing in frequency. (Figure 16).



Source: 02.12.2013 / Finnish Transport Safety Agency

It is good to remember that bird strikes are often under-reported. According to earlier studies, pilots report only 20–25% of bird strikes (Brown and Hickling, 2000). Therefore it is important to realise that the actual number of bird strikes is much higher than the number of bird strikes reported.

The best way to learn more about bird strikes and develop preventive tools against them is to collect as much data as possible about different aspects related to bird strikes. One of the most efficient ways to do this is trying to create a good reporting culture, which increases the number of bird strike reports received and improves their quality.

One problem is that even if the pilots are willing to report bird strikes, sometimes they simply are not aware of them. Especially if a small bird hits a large aircraft's wing or fuselage, the pilot may not notice the strike. For this reason, an after flight check is

important to detect any blood marks or bird remains left on the aircraft surface. This first check is often carried out by the ramp staff. Unfortunately, small blood marks or remains for example on the wing leading edge are quickly worn out if the aircraft is flying in rainy weather.

A large number of bird strike reports is made by airport maintenance staff after they have found dead birds on runways or in their vicinity. This fact shows that pilots seem to miss quite many strikes. Consequently, pilots should also be encouraged to report near misses and any cases where they suspect that they might have hit a bird. In fact, a representative of one large Finnish airline told in the Bird Strike Committee Finland meeting on 25th of September 2012 that they have lowered the reporting threshold and will now report any types of bird strikes, even those that did not cause any damage or that probably were only near misses.

In Finland, bird strike reporting is not a part of the mandatory incident reporting system, but it is strongly recommended by the Finnish Transport Safety Agency. The rules on whether bird strike reporting is voluntary or mandatory vary in different countries. For example, the United States have a voluntary reporting system, but in the Great Britain, bird strike reporting has been mandatory since the year 2004. In fact, on the 1st of January 2008, the CAA UK introduced a new system for reporting bird strikes online (CAA UK, 2008).

The Bird Strike Committee of Finland has a significant role in the prevention of bird strikes in Finland. The aim is to increase reporting activity and share knowledge about birds, bird strikes, good reporting practices, arctic migration and many other issues.

4.3 What Kind of Aircraft is the Most Sensitive to Bird Strikes?

This study proved the assumption that fast moving silent aircraft are the most sensitive to bird strikes. The types of aircraft operating in Finland in the years 2000, 2006 and 2011 are shown in Tables A1.7, A1.8 and A1.9.

During all years studied, 2000, 2006 and 2011, most of the bird strikes occurred to modern turbofan aircraft. The main reason is that new aircraft have quieter engines than the old ones. In addition, birds and other wildlife living in urban areas are so much used to engine noise that they feel comfortable in the vicinity of large airports and are not scared of aircraft (Dolbeer, 2011). Engine noise is an issue people are often complaining about if they live near airports or approach routes. Due to this, airlines want to keep their fleet as modern as possible, because low engine noise is one of the key issues sought after in any kind of power plant.

Aircraft speed is another significant parameter. Low and fast operating military aircraft have a lot higher risk to hit a bird than slower aircraft. It is also good to remember that the velocity of the aircraft can be relatively slow for example during take-off, but the engines are set to maximum power. At that time, a bird strike may cause significant damage to the engine blades.

Bird strikes may obviously happen to any kind of aircraft with any kind of engine. Nevertheless, a more precise analysis reveals that bird strikes seem to occur rarely at small airports, where take-offs and landings can only be made by helicopters or small reciprocating-engine aircraft. This study includes all bird strikes reported at Finnish airports and involving aircraft registered in Finland. The airports with top five frequencies in bird strike reporting also had frequent operations by turbofan-powered aircraft.

4.4 Time of Day When the Bird Strikes Occurred

Bird strikes occur at different times during a day. This study focused on bird strikes in Finland. Because Finland is located far up in the north, the day is very long in the summer and very short in the winter. Therefore, the times given in the reports analysed do not provide exact information on the visual conditions (day vs. night). In fact, during summer time (from middle of May to middle of August), the nights are so bright that the term “night time” is misleading. On the other hand, during winter

months (from middle of November to middle of February), the night time is so long and dark that the term “day time” may be misleading.

The proportion of reported bird strikes between 18:00 – 06:00 increased from year 2000 (20%) to 2011 (32%). At the same time, the number of reports in which the time was unknown remained almost the same. The reason for this is not clear, but it could be related to weather. Weather has a significant role in bird flying activity. For example, arctic migrations are heavily dependent on the weather.

4.5 Arctic Migrations

This study shows that the migrations have an influence on the number of bird strikes. In all studied years, 2000, 2006 and 2011, there is a clear peak in bird strikes in April. In the year 2006, the first reported bird strikes happened in April. In autumn, the bird strike numbers for September are almost the same as for April. Figure 11 shows the number of bird strikes by month in the years 2000, 2006 and 2011. However, corresponding figures published about the number of bird strikes in the UK between years 2005 and 2009 are different. In both countries, the high season for bird strikes seems to be in June, July and August, but in the UK, the migration months do not show up as clearly as in Finland (EASA, 2009).

The arctic migrations are a massive spectacle of nature, which gathers together even several hundred thousands of birds. The autumn migration is actually even more interesting than the spring migration. This is because birds do not have to hurry in moving south as long as the weather is good enough in the north. Birds do not start their migration as long as the temperature is suitable for them and some food is available. In Finland, the autumn migration may last from the beginning of May until the end of February, which actually covers almost the whole year. September is the most common month for the most species to move south.

The spring migration has been better studied than the autumn migration. Among the first signs of spring are the flocks of cranes, swans, geese and waterfowl flying from

south to north. The time frame of spring migration is shorter than that of autumn migration, because in spring, the birds seem to be in a hurry to get to their breeding areas quickly, to find a partner, build a nest, mate and lay eggs. The northern summer is short and the birds have no time to waste. The last arrivals of spring migration are hardly settled down when the first birds are already starting their autumn migration (Päärne, 2010).

Especially arctic spring migrations may vary significantly from one year to another. If the weather is bad during the heavy migration period and there are only few days with favourable weather, this may increase the risk for bird strikes.

The migration of arctic waders is a good example of this. The waders are flying very high if there is a good tailwind and the weather is good. The migration routes are then largely unknown, because the birds cannot be monitored from the ground. On the other hand, if the weather turns bad and the wind starts blowing from the north, this forces the birds to fly lower and they can be well observed from the ground.

Even if the weather is good, the wind direction below the altitude of 1 km may cause the birds to divert in a sideward direction. Wind from south–south-east to south-west pushes the birds towards the coastal areas of the Gulf of Finland and inlands to south-eastern Finland. On the contrary, wind from south-east to west pushes the birds to the open sea areas of the Gulf of Finland and towards Estonia, which means that the birds do not even enter the Finnish airspace. This has an influence especially on arctic waders, but also affects other birds.

Arctic migrations in the autumn are again different. First, the whole migration period is longer and it takes place from July to October, whereas the spring migration only lasts one month. Various species of geese are easiest to follow. If the wind blows from east to north-east, the goose migration activity is heavy in Finland. If the wind turns to blow from north to north-west, the number of birds observed is significantly lower. The main flocks pass Finland from the Russian side, and only some birds fly in the Finnish airspace.

Birds nesting in Finland always have to fly through Finland, and the migration occurs when the weather is good. Various small birds are best observed when they have to fly into a headwind. This causes them to fly low and they often form massive flocks in the south-western peninsulas, such as Porkkala and Hanko. In a good tailwind, the birds are flying higher and the number of observations is lower than in a moderate headwind. (Koistinen, 2013).

4.6 Weather

As mentioned in the previous section for arctic migrations, the weather has a significant impact on bird activity. It is unfortunate that weather details were so poorly reported. Local weather details provided by pilots, air traffic controllers or airport maintenance staff are highly valuable when analysing and studying bird strikes. Weather details were reported a lot better in the year 2000 than ten years later in 2011.

The weather influences the birds' flight strategy, foraging behaviour and most of all, their flight altitudes. Especially those species using thermal convections fly at totally different altitudes in good weather. In contrast, the birds that fly more powered flight are not that much influenced by the weather (Shamoun-Baranes et al., 2006). The impact of the weather can be more significant than the time of day. This is a significant fact especially during migrations. The birds can be waiting for an optimal wind for days and build up massive flocks. During low pressure, birds are waiting on fields or just a few individuals will migrate in a fairly narrow front. But as soon as the high pressure comes, the birds will immediately start to move (Päärne, 2010). In Finland, the wind direction has to be from north-east for autumn migration and from west for spring migration.

4.7 Phase of Flight When the Bird Strikes Occurred

Approach is the most sensitive phase of flight as concerns bird strikes. In the Finnish bird strike reports analysed during years, 2000, 2006 and 2011, more than one third of the strikes were reported to have happened during approach. The altitude can explain this, as during approach, the aircraft is flying low for a fairly long time, whereas in take-off, it climbs to a safe altitude at a relatively steep angle. Some bird strikes also happen during initial climb, which means the period from rotation to the moment when climb is established. It has been noted that birds very often prefer to stay at the end of a runway, which leads to a higher risk for large aircraft which need a longer take-off distance (Chilvers, 1997).

In this study, there were no reported bird strikes during initial climb or take-off run for the year 2000. Ten years later in 2011, however, 42 (19%) of the reported bird strikes took place during initial climb. One reason for this could be that the pilots reported the flight phase more accurately in the year 2011 than in 2000. Nevertheless, it could also be due to the fact that many of the aircraft operating in 2011 were larger than those operating ten years ago. For example, according to the data collected on aircraft movements at Finnish airports, large wide-bodied Airbus A330 and A340 aircraft made a total of 17 take-offs and landings in year 2000, while ten years later in 2011, those aircraft types had 4,210 take-offs and landings. Aircraft movements, also reviewed by aircraft and engine category, are shown in Tables A1.7, A1.8 and A1.9.

4.8 About Heights and Altitudes

Bird strikes normally occur below the altitude of 500 feet during take-offs and approaches. In the year 2000, 101 (59%) of the strikes happened at or below 500 feet altitude. In the year 2011, 93 (42%) of the strikes were reported to have taken place at or below 500 feet altitude.

The National Wildlife Strike Database for Civil Aviation in the United States received 38,961 reports of bird strikes between the years 1990–2004. Of those bird strikes,

10,143 (26%) occurred above 500 feet altitude (Dolbeer, 2006). Later a trend was found suggesting that the number of bird strikes above 500 feet was increasing. In Dolbeer's (2011) later study, it was revealed that the number of bird strikes occurring above 500 feet had actually increased from the year 1990 up to 30% between the years 2005 to 2009. This study shows that exactly the same trend could also be seen in Finland based on the bird strike reports received by the Finnish Transport Safety Agency. The share of bird strikes above 500 feet increased from 71 (41%) in the year 2000 up to 129 (58%) in the year 2011. This means a total increase of 29% from 2000 to 2011.

Bird strikes above 500 feet were most often caused by waterfowl, gulls, terns, passerines and vultures. As for the bird strikes below 500 feet, they happened most frequently to passerines, gulls, terns, pigeons, doves and raptors (Dolbeer, 2011). According to the bird strike reports received by the Finnish Transport Safety Agency in the years 2000, 2006 and 2011, bird strikes above 500 feet were most often caused by swallows, swifts and Sand Martins (*Riparia riparia*).

The strikes causing damage to aircraft most often occurred above 500 feet altitude (66%). Dolbeer (2011) also discovered that the relative number of aircraft-damaging bird strikes had increased from 37% in 1990 up to 45% by the end of year 2009.

According to this study, 12 (7%) of the bird strikes caused some damage to the aircraft in the year 2000. Of the aircraft-damaging bird strikes, 7 (58%) took place at or below 500 feet, 4 (33%) occurred above 500 feet and in one case (8%), the altitude was unknown or not reported.

During the year 2006, 8 (6%) bird strikes were reported to have caused some damage to the aircraft. Two (25%) of the aircraft-damaging bird strikes happened below 500 feet and four (50%) above 500 feet. In two cases (25%), the altitude was not reported or not known.

In the year 2011, 11 (5%) of the bird strikes caused some damage to the aircraft. Three (27%) of the aircraft-damaging bird strikes happened at or below 500 feet

altitude. The same number, three (27%), took place above 500 feet. In five (45%) of the reports the altitude was not unknown or not reported.

Contrary to Dolbeer's (2011) study, the number of bird strikes causing aircraft damage decreased in Finland by 29% during the years studied, from year 2000 to 2011.

4.9 Trends

When analysing the results for the years studied, 2000, 2006 and 2011, some trends and similarities can be observed:

- Time of year when the bird strikes occurred. Summer is clearly the worst season especially for bird strikes that happen at airports or near vicinity. This can be explained by the fact that airports provide an ideal environment for birds for nesting and finding food. Large grass areas attract various insects and small rodents, which in turn bring the birds looking for food. Later, when young birds are leaving their nests, they are simply not careful enough and can easily be hit by aircraft. The number of aircraft operations is not higher in summer.
- Altitude where the bird strikes happened. Most of the reported bird strikes occurred below 2000 feet. This fact also correlates strongly with the phase of flight. If the aircraft starts its approach to an airport from 2000 feet by using a three-degree glide, it will be flying at the altitude where bird strikes most frequently occurred for about 9 km. Departing aircraft normally climb in a 10-degree "nose up" angle, which means that the aircraft reaches the altitude of 2000 feet after flying a distance of about three kilometres.
- Size of bird that hit the aircraft. Small birds are causing the major part of all bird strikes reported in Finland. This could be explained by the fact that small birds often eat insects, which they can easily find at airports in the summer. Airports seem to be an ideal environment for small birds. One reason could also be that small birds are not perceived as significant a flight safety issue as they could be.

In addition, individual small birds or minor flocks of them are not as easily seen by pilots or air traffic controllers as larger birds, and preventive actions may be taken too late or not at all. Most preventive actions are directed towards medium and large birds. For example at Helsinki-Vantaa International Airport, there is a very strict zero tolerance against any geese. They will be immediately eliminated.

- Identification of bird species. Different bird species were poorly identified. The number of identified birds remained low during the years studied, and it even dropped from 30% in the year 2000 down to 10% in the year 2011. The reason for this is simple: pilots, air traffic controllers and airport maintenance staff just do not know the species of birds, and for example DNA testing is not used.
- Types of aircraft that were hit by birds. Turbofan powered aircraft are most sensitive to bird strikes. This is explained by the fact that most flight operations are carried out by turbofan aircraft. Turbofan aircraft are fast moving and relatively quiet as well. The power plant is often located under the wing, fairly low above the runway and taxiway surface. Many birds can be easily sucked into the engine due to this.

Chapter 5: Conclusion

5.1 Introduction

For over a hundred years, bird strikes have been a serious safety issue for the aviation business. Year after year the sky is becoming busier, both for aircraft and the birds, and the risk of bird strikes is increasing. Many studies have been carried out on this subject and a lot of different practices and tools have been developed to prevent bird strikes. Even so, bird strikes do occur every day, and unfortunately their number is increasing.

5.2 Conclusion of this Study

In this study, many interesting observations and conclusions have been made. Some recommendations are also given based on the findings.

5.2.1 Quality of Bird Strike Reports

The quality of bird strike reports varies a lot. In this study nine variables were followed and every year was different. The major differences in reporting were easy to find out. As in any occurrence reporting, good quality is more valuable than a large number of reports.

A poorly completed bird strike report is like an empty lot; it provides no information or only very little information for further research. Persons filling up bird strike report forms should make sure that they complete the form properly. Especially those reports where the bird strike did not cause any damage and had no effect on the flight are often filled up poorly, and a lot of valuable data is missing. One interesting finding was how poorly weather details were reported in the bird strike reports for year 2011.

A significant improvement was that the phase of flight was marked a lot better in the reports for year 2011 than for year 2000.

One solution for improving the quality of reports could be to make certain fields on the web-based bird strike report form mandatory to fill in before the report can be sent. In this way the bird strike reports would become more useful for future studies and prevention activities.

The report is often the only source of information for those involved in airport wildlife management and for regulators, for example. As in any other incident reporting, a large number of reports are not a sign of many problems – rather just the opposite; it indicates a good reporting culture. The benefits of bird strike reporting are more easily achieved if the quality and quantity of the reports is high. In conclusion, bird strike reporting should be made mandatory.

5.2.2 Quantity of Bird Strike Reports

The quantity of bird strike reports has been increasing since the year 2008 ($n = 117$). The number of bird strike reports received by the Finnish Transport Safety Agency was over 300 in the year 2012. This means a nearly 180% improvement in reporting activity. At the same time, the number of aircraft movements at Finnish airports has decreased. The total number of landings in the year 2000 was 225,025, while the corresponding figure for the year 2011 was 210,230 (Table A1.7). Concluding from this, there were altogether 14,795 (7%) less landings but 50 (23%) more bird strike reports in the year 2011 compared to the year 2000. Pilots, air traffic controllers and airport maintenance staff have clearly lowered the threshold for filing a bird strike report.

5.2.3 Identification of Bird Species

This study proved that the birds are identified poorly. In the year 2011, the bird was correctly identified only in 22 (10%) out of 222 bird strikes.

The problem of identifying the birds is common everywhere. It cannot be expected that pilots, air traffic controllers and airport maintenance staff would be able to identify all the bird species, but some kind of training should be provided on the subject. Bird strikes often occur at the airport or in its vicinity, and the people who are working at the same airport for years often learn to know the local birds. For example Helsinki-Vantaa Airport has a flock of crows (*Corvus corone*), some of which have been ringed. The oldest crows in that flock are over 15 years old and familiar to many of the workers.

Stenman and Joutsen (2013) have written a booklet that introduces all the species of seagulls living in Finland and contains information on how to prevent them at airports. This is an excellent idea to increase the aviators' knowledge about birds. In the near future, the Finnish Transport Safety Agency's web-based reporting system will also have an option to add a picture to the online report. This will give a possibility, for instance, to add a picture of a bird that the pilot could not identify. Those pictures could then be forwarded to the Finnish Natural Museum's ornithologists or they could be discussed in the Finnish Bird Strike Committee meetings, where there are members with better competence in identifying various bird species. In some cases, DNA testing should also be a possibility.

5.2.4 Types of Aircraft and Reported Bird Strikes

Aircraft types operating in Finland are now different than over ten years ago. This can also be seen in bird strike reports. It is obvious that aircraft which have the largest share of landings and take-offs also have the most bird strikes. A clear rule of thumb is that modern turbojet aircraft are the most sensitive to bird strikes. In Finland, one operator also uses many ATR72 and ATR42 aircraft on domestic flights. A

significantly larger number of take-offs and landings shows clearly as an increasing number of bird strike reports. An interesting observation was that concerning helicopters. Helicopters do not have many operations in Finland, but the probability of bird strikes is nearly as high as for turbopropeller aircraft.

5.3 Recommendations for Future Research

This study brought up some questions and areas of study that could be interesting subjects for future research.

- What are the differences between mandatory and voluntary bird strike reporting? Is the quality of reports better if bird strike reporting is mandatory and is the number of reports higher in relation to aircraft movements?
- What would be the best way to give information to the pilots about heavy bird activity? Should the air traffic controller, for example, suggest another runway for approaching aircraft if a flock of birds is seen in the approach sector?

REFERENCES:

- Airbus (2012), “Demand spurs need for over 28,000 aircraft in the next 20 years”, available at: <http://www.airbus.com/presscentre/pressreleases/press-release-detail/detail/demand-spurs-need-for-over-28000-aircraft-in-the-next-20-years/> (accessed 18th September 2012).
- Baxter, A.T. and Robinson, A.P. (2007), “Monitoring and influencing feral Canada goose (*Branta Canadensis*) behaviour to reduce birdstrike risk to aircraft”. International Journal of Pest Management, Vol. 53, No. 4, p. 341-346.
- BBC News (2012), “Nepal plane crash: UK dead remembered”, available at: <http://www.bbc.co.uk/news/world-asia-19754351> (accessed 29th September 2012).
- Benton, T.G. et al. (2002), “Linking Agricultural Practice to Insect and Bird Populations: A Historical Study Over Three Decades”. Journal of Applied Ecology, Vol. 39, p. 673-687.
- BirdLife Suomi – Finland (2012), “Barnacle Goose (*Branta leucopsis*) and Great Cormorant (*Phalacrocorax carbo*)” (in Finnish), available at: <http://www.birdlife.fi/suojelu/lajit/valkoposkihanhi.shtml> and <http://www.birdlife.fi/suojelu/lajit/merimetso.shtml> (accessed 7th September 2012).
- BirdLife Suomi – Finland (2012), “Birds in Finland” (in Finnish), available at: http://www.birdlife.fi/havainnot/rk/suomessa_tavatut_lintulajit.shtml (accessed 7th September 2012).
- Brown, J. and Hickling, G. (2000), “The problems of analysis of pilot-reported bird-strikes as an index for actual bird-strikes at airports”. New Zealand Journal of Zoology, Vol. 27, p. 45-47.
- caa.co.uk (2008), United Kingdom Civil Aviation Authority, CAA Introduces Online Birdstrike Reporting System, available at: <http://www.caa.co.uk/application.aspx?catid=14&pagetype=65&appid=7&newstype=n&mode=detail&nid=1548> (accessed 25th August 2012).
- Chilvers, B.L. et al. (1997), “Factors affecting pilot-reported bird-strike rates at Christchurch International Airport, New Zealand”. New Zealand Journal of Zoology, Vol. 24, p. 1-7.
- Dolbeer, R.A. (2006), “Height Distribution of Birds Recorded by Collisions with Civil Aircraft”. Journal of Wildlife Management, Vol. 70, No. 5, p. 1345-1350.

Dolbeer, R.A. (2011), “Increasing trend of damaging bird strikes with aircraft outside the airport boundary: implications for mitigation measures”. *Human-Wildlife Interactions*, Vol. 5, No. 2, p. 235-248.

Dove, C.J. (2008), “Using DNA Barcodes to Identify Bird Species Involved in Birdstrikes”. *Journal of Wildlife Management*, Vol. 72, No. 5, p.1231-1236.

Dove, C.J et al. (2010), “Using Whatman FTA® cards to collect DNA for bird-strike identifications”. *Human-Wildlife Interactions*, Vol. 5, No. 2, p. 218-223.

European Aviation Safety Agency (EASA) (2009), “Bird population trends and their impact on aviation safety 1999 – 2008”. EASA safety report 2009.

European Commission (2008), Commission Regulation (EC) No 859/2008 of 20 August 2008 amending Council Regulation (EEC) No 3922/91 as regards common technical requirements and administrative procedures applicable to commercial transportation by aeroplane. *Official Journal of the European Union*.

European Union (2003), Directive 2003/42/EC of the European Parliament and of the Council of 13 June 2003 on occurrence reporting in civil aviation. *Official Journal of the European Union*.

European Union (2010), Regulation (EU) No 996/2010 of the European Parliament and of the Council of 20 October 2010 on the investigation and prevention of accidents and incidents in civil aviation and repealing Directive 94/56/EC. *Official Journal of the European Union*.

Fernandez-Juricic, E. et al. (2011), “Bird strikes and aircraft fuselage color: a correlation study”. *Human-Wildlife Interactions*, Vol. 5, No. 2, p. 224-234.

Finnish Aviation Act (2009), No. 1194/2009. Issued in Helsinki, 22 December 2009.

Finnish Aviation Regulation (1997) AGA M3-13, “Lintujen ja muiden eläinten torjunta lentoasemilla”. Issued in Helsinki, 23 January 1997. Also available in English: Prevention of birds and other wildlife at airports, http://www.trafi.fi/filebank/a/1320403265/59250a8145d7ce529b9e5901428fcfb7/553-agr3_13.pdf

Finnish Aviation Regulation (2011) GEN M1-4, “Onnettomuuksista, vakavista vaaratilanteista ja poikkeamista ilmoittaminen”. Issued 16 March 2011 in Helsinki. Also available in English: Reporting of accidents, serious incidents and occurrences, http://www.trafi.fi/filebank/a/1320403287/5dc8ecf182fea60aaed16d5aa7db2396/627-GEN_M1-4_2011_eng.pdf

Finnish Aviation Regulation (2009) OPS M1-18, “Vaarallisten aineiden ilmakuljetus”, (Transportation of Dangerous Goods by Air) (In Finnish). Issued in Helsinki, 15 June 2009.

Safety Investigation Act (2011), No. 525/2011. Issued in Helsinki, 20 May 2011.

Gauthreaux, S. A. Jr and Belser, C. G (2003), “Overview Radar Ornithology and Biological Conservation”. Auk Vol. 120, No. 2, p. 266-277.

International Air Transport Association (IATA) (2012), Annual Report 2012, 68th Annual General Meeting, Beijing – June 2012.

International Bird Strike Committee (IBSC) (2006), “Recommended practices No. 1. Standards for Aerodrome Bird / Wildlife Control”. Issue 1 – October 2006.

International Civil Aviation Organization, ICAO Annex 13, “Aircraft accident and incident investigation”. Tenth Edition 2010.

International Civil Aviation Organization, ICAO Annex 14, “Aerodromes”. Fourth Edition 2004.

Joint Aviation Authorities (JAA), Administrative & Guidance Material, Leaflet No 44, Section 4 / Part 3 (JAR-OPS). June 2008.

Jonzén, N. et al. (2006), “Rapid Advance of Spring Arrival Dates in Long-Distance Migratory Birds”, Science AAAS (American Association for the Advancement of Science), Vol. 312, p.1959-1961.

Kelly, T.A. (2009), “Beware of the birds”. IEEE Potentials, Vol. 28, No. 5, p.31-35.

Koistinen, J, interview by Jukka-Pekka Nikolajeff. Senior Research Scientist in Meteorology (Nov 2013).

Layborne, R.C. (1974), “Collision Between a Vulture and an Aircraft at an Altitude of 37,000 feet”. Wilson Bulletin, Vol. 86, No. 4, p. 461-462.

LeMieux, J. Dr. (2009), “One Bird Strike & You’re Out!”, Solutions to prevent bird strikes. Victoria, BC, Canada.

Martin, G.R. (2011), “Understanding Bird Collisions with Man-Made Objects: a Sensory Ecology Approach”. IBIS (The International Journal of Avian Science), Vol. 153, p. 239-254.

Miller, F. P et al. (2010), “Bird Strike”, Alphascript Publishing, Mauritius.

Njå, O et al. (2012), “Risk of bird strikes – A discussion of current tools and practices”. Study presented in International Bird Strike Committee (IBSC) meeting in Stavanger, Norway, 25–29 June 2012.

Parsons, J.G et al. (2009), “Bat Strikes in the Australian Aviation Industry”, *The Journal of Wildlife Management*, Vol. 73, No. 4, p. 526-529.

Päärni, J. (2010), “Lintujen syysmuuttoa pääkaupunkiseudulla”, (Birds’ autumn migration in the Helsinki metropolitan area), Kariston kirjapaino Oy, Hämeenlinna, Finland (In Finnish).

Raulot, M. (2009), Bird strike management at airports: a case study in French airports (published MSc thesis), Cranfield University, Cranfield.

Shamoun-Baranes, J. et al. (2006), “A Comparative Analysis of the Influence of Weather on the Flight Altitudes of Birds”, *Bulletin of the American Meteorological Society*, Vol. 87 p. 47-61.

Shamoun-Baranes, J. et al. (2008), “Avian Information Systems: Developing Web-Based Bird Avoidance Models”, *Ecology and Society*, Vol.13, No. 2, Art.38.

SKYbrary (2012), Category: Bird Strike, available at:
http://www.skybrary.aero/index.php/Category:Bird_Strike (accessed 17th of September 2012).

Stenman, O. and Joutsen, J (2013), “Lokkien tunnistaminen ja torjunta lentoasemilla”, (Identification and prevention of seagulls at airports), Finavia, Libris Oy, Helsinki (In Finnish).

Thorpe, J. (2012), “100 years of fatalities and destroyed civil aircraft due to bird strikes”, Study presented in International Bird Strike Committee (IBSC) meeting in Stavanger, Norway, 25–29 June 2012.

Transport Canada (2004), “Sharing the Skies – An Aviation Industry Guide to the Management of Wildlife Hazards”, Second Edition.

Tables

Table A1.1.

Aircraft movements at Finnish airports in years 2000, 2006 and 2011

	2000		2006		2011	
	Take-offs	Landings	Take-offs	Landings	Take-offs	Landings
Helsinki EFHK	82,809	82,842	91,113	91,111	97,121	97,125
Helsinki-Malmi EFHF	19,511	19,547	18,910	18,749	16,898	16,245
Tampere EFTP	15,790	15,769	14,242	14,226	13,467	13,387
Turku EFTU	14,263	14,230	11,378	11,336	11,138	11,121
Oulu EFOU	10,595	10,592	9,414	9,408	10,849	10,837
Kuopio EFKU	9,326	9,320	8,739	8,733	9,072	9,067
Jyväskylä EFJY	9,903	9,782	11,128	11,048	9,011	8,991
Rovaniemi EFRO	10,311	10,251	8,513	8,483	7,580	7,558
Vaasa EFVA	7,364	7,216	6,521	6,419	5,649	5,611
Pori EFPO	7,072	7,039	5,530	5,545	5,390	5,338
Kauhava EFKA	7,936	7,924	5,750	5,760	4,871	4,860
Mariehamn EFMA	4,973	4,994	3,884	3,852	3,411	3,446
Kokkola-Pietarsaari EFKO	3,687	3,580	2,921	2,831	2,567	2,530
Joensuu EFJO	2,990	2,962	2,511	2,512	2,283	2,272
Kemi-Tornio EFKE	2,109	2,085	1,571	1,525	1,996	1,979
Utti EFUT	2,122	2,105	2,348	2,303	1,950	1,952
Kittilä EFKI	1,934	1,898	1,577	1,560	1,491	1,492
Halli Kuorevesi EFHA	2,176	2,141	1,717	1,650	1,310	1,171
Kajaani EFKA	1,658	1,690	935	993	1,220	1,220
Lappeenranta EFLP	4,097	4,089	2,289	2,286	1,176	1,156
Ivalo EFIV	1,407	1,396	1,021	1,058	881	878
Kuusamo EFKU	908	918	773	795	812	809
Savonlinna EFSA	1,232	1,255	908	903	638	622
Varkaus EFVA	1,167	1,187	642	641	491	492
Enontekiö EFEN	216	213	62	63	71	71
Total	225,556	225,025	214,397	213,790	211,343	210,230

Source: 15.11.2013 / Finavia Corporation

Table A1.2.

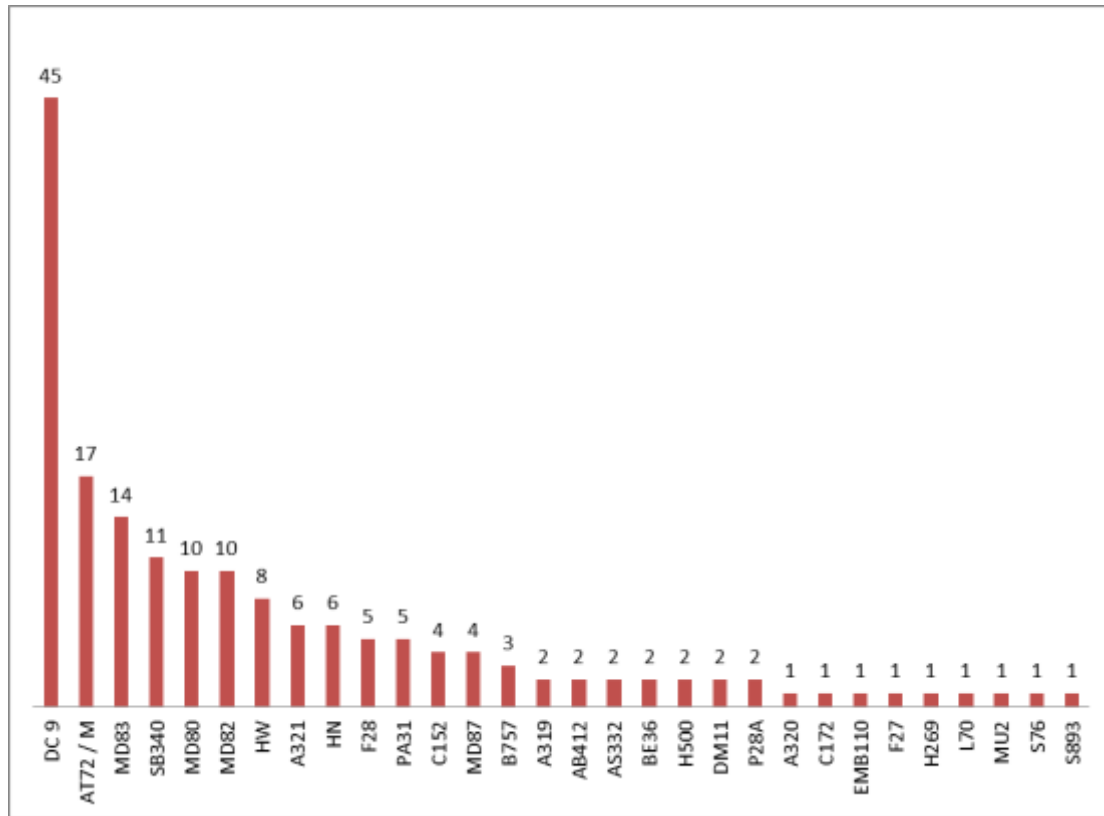
Aircraft movements at Finnish airports between 2000 and 2011

Year	Take-offs	Landings	Total
2000	225,556	225,025	450,581
2001	220,233	219,567	439,800
2002	208,377	207,937	416,314
2003	204,185	203,867	408,052
2004	212,568	212,501	425,069
2005	212,184	211,962	424,110
2006	214,397	213,790	428,187
2007	213,267	213,006	426,273
2008	214,917	215,055	429,972
2009	204,121	203,561	407,683
2010	199,871	198,813	398,684
2011	211,343	210,230	421,573

Source: 05.11.2012 / Finavia Corporation

Table A1.3.

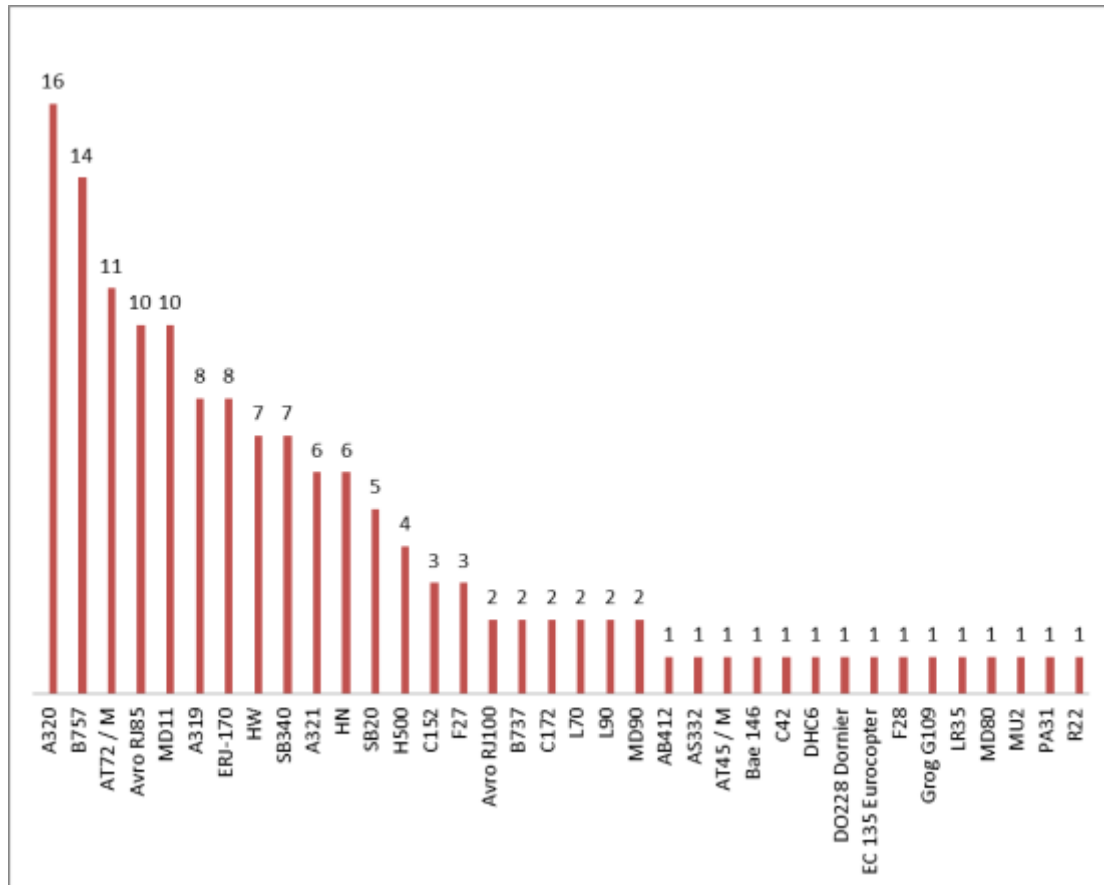
Number of reported bird strikes by type of the aircraft in the year 2000



Source: 02.12.2013 / Finnish Transport Safety Agency

Table A1.4.

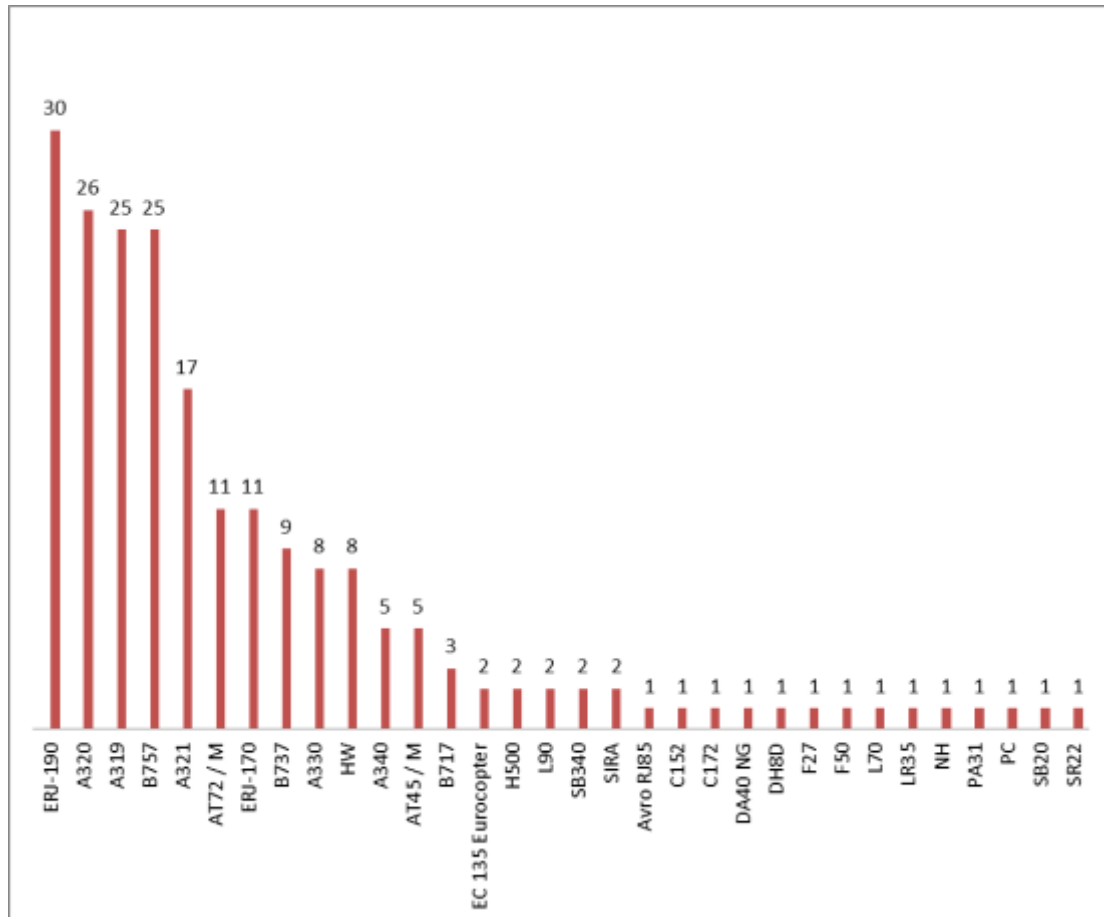
Number of reported bird strikes by type of the aircraft in the year 2006



Source: 02.12.2013 / Finnish Transport Safety Agency

Table A1.5.

Number of reported bird strikes by type of the aircraft in the year 2011



Source: 02.12.2013 / Finnish Transport Safety Agency

Table A1.6.**List of abbreviations of aircraft types**

Abbreviation	Aircraft type
A319	Airbus A319
A320	Airbus A320
A321	Airbus A321
A330	Airbus A330
A340	Airbus A340
A343	Airbus A343
AB412	Agusta Bell 412
AS332	Super Puma
AT45 / M	Alenia ATR 42
AT72 / M	Alenia ATR 72
AW119 Koala	AW119 Koala
Avro RJ100	Avro RJ100
Avro RJ85	Avro RJ85
B717	Boeing 717
B733	Boeing 733
B737	Boeing 737
B738	Boeing 738
B757	Boeing 757
BAe 146	Bae 146
Bae Jetstream 32	Bae Jetstream 32
BD-700 Bombardier	BD-700 Bombardier
BE36	Bonanza
C152	Cessna 152
C172	Cessna 172
C-295 CASA	CASA C-295
C30 Challenger, Bombardier	C30 Challenger, Bombardier
C42	Ikarus C 42
C56X Cessna Citation	Cessna Citation Excel
DA40 NG	Diamond Aircraft
DC 9	McDonnell Douglas DC-9
DC-10	McDonnell Douglas DC-10
DH8D	Dash 8
DHC6	DHC-6 Twin Otter
Diamond DA42	Diamond DA42
DO228 Dornier	DO228 Dornier
EC 135 Eurocopter	EC 135 Eurocopter
EMB110	Embraer EMB-110 Bandeirante

EMB-500 Phenom 100	EMB-500 Phenom 100
ERJ-170	Embraer 170
ERJ-190	Embraer 190
F27	Fokker F-27
F28	Fokker F-28
F406 Caravan II, Cessna	F406 Caravan II, Cessna
F50	Fokker F-50
Falcon 2000	Falcon 2000
G 450 Gulfstream	G 450 Gulfstream
Grog G109	Grog G109
H269	Hughes 269
H500	Hughes 500
HN	F/A-18 Hornet
HW	Hawk
L70	Valmet L-70 Vinka
L90	Valmet L-70 RediGo
LR35	Learjet 35
MD11	McDonnell-Douglas / Boeing MD-11
MD80	McDonnell Douglas MD-80
MD81	McDonnell Douglas MD-81
MD82	McDonnell Douglas MD-82
MD83	McDonnell Douglas MD-83
MD87	McDonnell Douglas MD-87
MD88	McDonnell Douglas MD-88
MD90	McDonnell Douglas MD-90
MU2	Mitsubishi MU-2
NH	NHIndustries NH90
P28A	Piper Archer
PA31	Piper PA-31
PC	Pilatus
R22	R22 Robinson
S76	Sikorsky S-76
S893	S893 Socata Rally 180T
SB20	Saab 2000
SB340	Saab 340
SIRA	SIRA
SR22	SR22 Cirrus

Source: 27.11.2013 / Finnish Transport Safety Agency

Table A1.7.**Aircraft take-offs and landings at Finnish airports by aircraft and engine category in years 2000, 2006 and 2011**

Aircraft	2000		2006		2011	
	Take-offs	Landings	Take-offs	Landings	Take-offs	Landings
1P	44,130	43,879	37,137	36,765	31,289	30,501
1T	3,312	3,287	4,103	4,070	6,074	6,023
2P	7,013	7,022	7,270	7,256	3,159	3,162
2T	9,522	9,557	12,487	12,504	10,691	10,703
3+T	121	116	162	165	17	17
JT	32,986	33,082	11,517	11,541	7,144	7,083
A320	5,829	5,839	34,150	34,184	32,965	32,963
A330	16	16	5	6	2 513	2 514
A340	1	1	243	243	1 697	1 696
AT45	0	0	6,330	6,337	7,599	7,609
AT72	26,854	26,817	17,482	17,490	25,008	24,999
B712	0	0	0	0	7,696	7,701
B737	5,930	5,936	5,969	5,978	12,803	12,805
B757	3,573	3,574	4,685	4,686	3,660	3,656
E170	0	0	8,967	9,003	8,054	8,055
E190	0	0	30	31	12,235	12,235
F100	723	725	613	614	527	525
MD11	1,305	1,309	2,029	2,028	384	383
MD80	29,348	29,355	5,292	5,316	1,100	1,100
MD90	290	289	2,692	2,695	10	10
RJ85	21	23	10,814	10,811	4,954	4,948
SF34	19,574	19,601	12,627	12,649	2,617	2,618
MIL	21,785	21,362	15,979	15,736	14,232	14,106
HECO	12,118	12,095	8,420	8,388	8,669	8,731
OTHERS	1,105	1,140	5,394	5,294	6,241	6,083
Unknown	0	0	0	0	5	4
Total	225,556	225,025	214,397	213,790	211,343	210,230

Source: 15.11.2013 / Finavia Corporation

Table A1.8.

Total aircraft take-offs and landings at Finnish airports by aircraft and engine category in years 2000, 2006 and 2011

Aircraft	Total	
	Take-offs	Landings
1P	112,556	111,145
1T	13,489	13,380
2P	17,442	17,440
2T	32,700	32,764
3+T	300	298
JT	51,647	51,706
A320	72,944	72,986
A330	2,534	2,536
A340	1,941	1,940
AT45	13,929	13,946
AT72	69,344	69,306
B712	7,696	7,701
B737	24,702	24,719
B757	11,918	11,916
E170	17,021	17,058
E190	12,265	12,266
F100	1,863	1,864
MD11	3,718	3,720
MD80	35,740	35,771
MD90	2,992	2,994
RJ85	15,789	15,782
SF34	34,818	34,868
MIL	51,996	51,204
HECO	29,207	29,214
OTHERS	12,740	12,517
Unknown	5	4
Total	651,296	649,045

Source: 15.11.2013 / Finavia Corporation

Table A1.9.

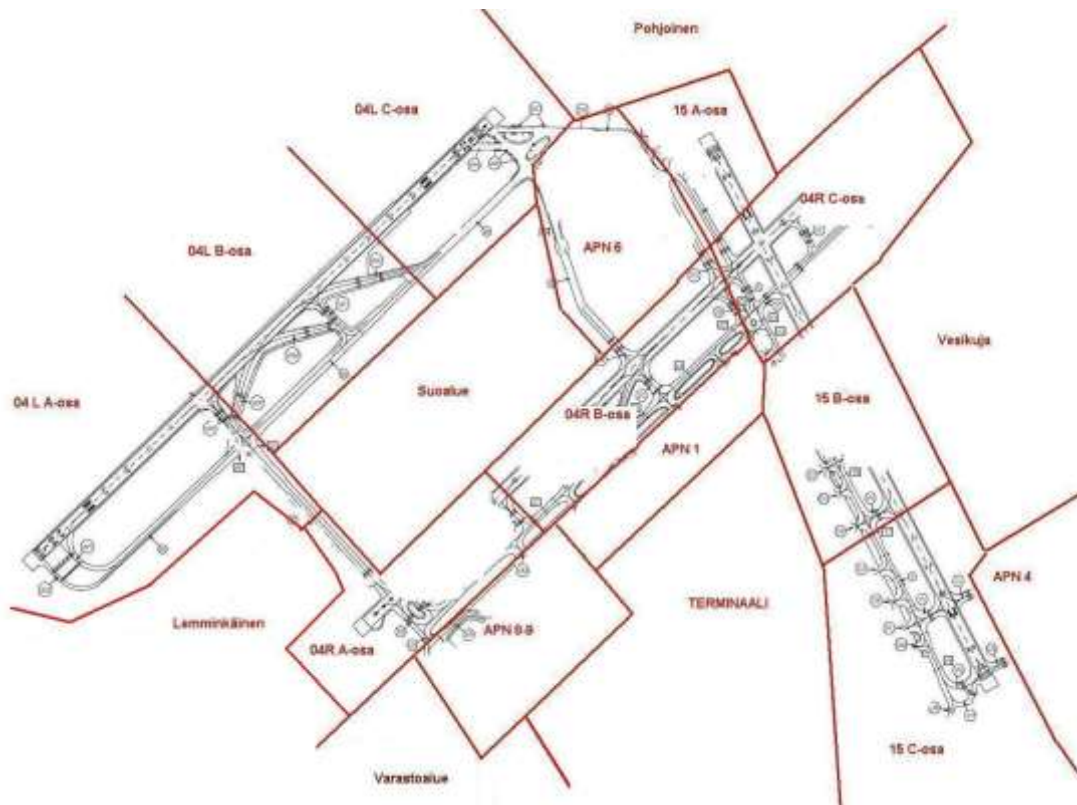
List of abbreviations of aircraft and engine categories

1P	single-engine reciprocating
1T	single-engine turbopropeller
2P	twin-engine reciprocating
2T	twin-engine turbopropeller
3+T	3+ -engine turbopropeller
JT	Other turbofan transport category
A320	A320-series, turbofan transport category
A330	A330-series, turbofan transport category
A340	A340-series, turbofan transport category
AT45	AT45, 2-engine, turbopropeller
AT72	ATR72, 2-engine, turbopropeller
B712	B712 turbofan
B737	B737-series, turbofan transport category
B757	B757-series, turbofan transport category
E170	Embraer E170, turbofan transport category
E190	Embraer E190, turbofan transport category
F100	F100 turbofan
MD11	MD11, turbofan transport category
MD80	MD80-series, turbofan transport category
MD90	MD90-series, turbofan transport category
RJ85	Avro Regional Jetlines 85, turbofan transport category
SF34	SF340, 2-engine turbopropeller
MIL	military
HECO	helicopter
OTHERS	other

Source: 26.4.2012 / Finavia Corporation

Table A1.10.

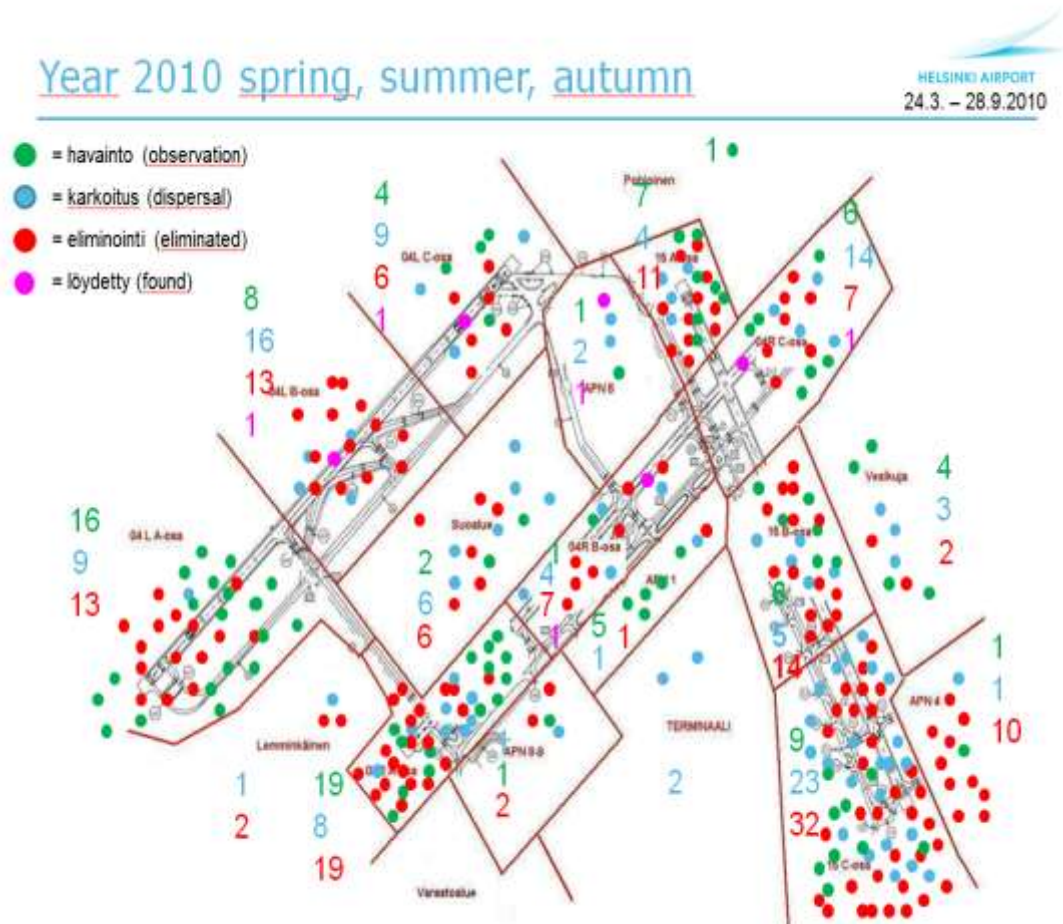
Helsinki-Vantaa International Airport (EFHK) wild life management map



Source: 18.10.2013 / Finavia Corporation

Table A1.11.

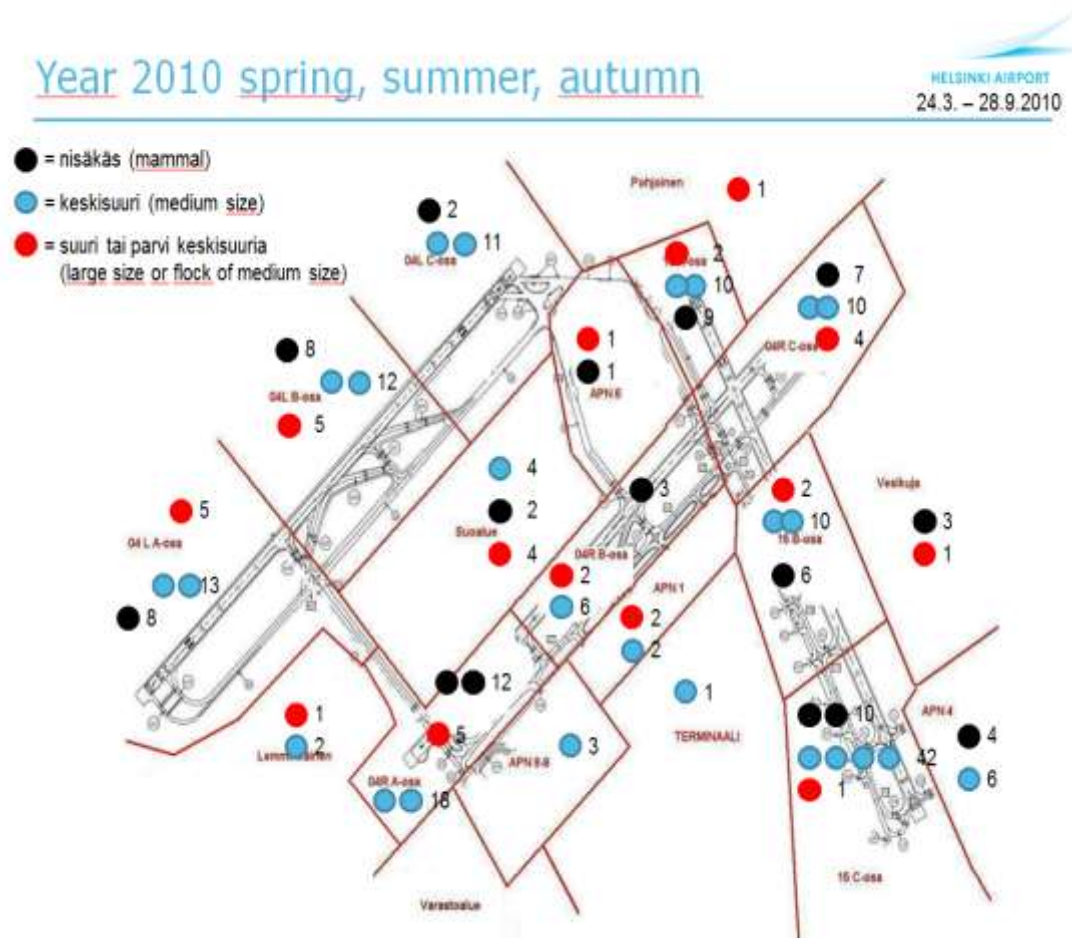
Helsinki-Vantaa International Airport (EFHK) wild life actions



Source: 18.10.2013 / Finavia Corporation

Table A1.12.

Helsinki-Vantaa International Airport (EFHK) type of wild life observations



Source: 18.10.2013 / Finavia Corporation