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Birds vs. Metalic Birds: A review of Bird Strikes in Aviation

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Abstract

This study gathered statistical data about bird strikes from various countries, including Türkiye. The study aims to compare the bird strike events that occurred in Türkiye and other countries by investigating bird strike data analysis from targeted countries. In this context, data on bird strikes per 10000 flights, distribution of the number of birds strikes according to months, phases of flight, the components hit by the birds, and the time of the event occurred on a day were presented. The data includes findings from Türkiye, USA, UK, Australia, Finland, Iran, and Czechia. When the results were evaluated, it was concluded that bird strikes are an essential factor to consider for safety and risk management. It is crucial that countries must conduct regular reporting to manage this safety issue. With the help of appropriate modelling conducted via proper measurements, the industry will come a long way in solving the safety issues caused by bird strikes.

1. Introduction

According to the aviation industry, a bird strike is expressed as the collision of aircraft with birds during any phase of flight. Along with the increasing air traffic, the probability of collision is also increasing every day (Dolbeer et al., 2005; Hedayati & Sadighi, 2015). Even though collisions can occur during any phase of the flight, the fact that bird strikes occur more often during the take-off and landing phases due to the more intense bird activity (Juračka et al., 2021; Metz et al., 2021). In addition, it was observed that these impacts caused serious damage, especially on the surfaces of the aircraft that were first exposed to the flow, such as the radome, wing leading edges, and engines (Metz et al., 2020). Bird strikes are not only a severe problem affecting commercial air transport and general aviation but also an issue affecting military aviation. As a result of bird strikes, the flight decks or primary control surfaces of small single-engined aircraft used in general aviation activities were damaged, while engine damage was observed in aircraft used in commercial air transport. Many of these collisions have not been of such primary priority as to affect the control capabilities of pilots over the aircraft. When the collisions occurring in the engines are examined, it is observed that the cases of engine stops occur at low rates (Airbus, 2004). One of the important reasons for this situation is that general aviation aircraft are flying at a low altitude compared to commercial transport aircraft. The disadvantage of commercial passenger aircraft in this scenario is that they receive structural damage at a level that will prevent the sealing of any region that has been pressurized as a result of a bird strike. Also, due to the fact that they are primarily jet-powered, their high speed has reduced the avoidance reflexes of pilots and birds (Ucer, 2001).

It is estimated that the number of fatal accidents due to bird strike between 1912 and 2008 was 54, and a total of 276 people lost their lives in these accidents. Among these 54 accidents, 7 were caused by helicopters, 32 were caused by aircraft weighing 5700 kg and less, and 15 were caused by aircraft weighing more than 5700 kg and business jets. Having only one fatal accident of a jet-powered airliner around the world out of over 1.4 million flight hours shows the increased awareness about the bird strike and related measures (Thorpe, 2009).

Nowadays, researchers have focused on studies of bird strikes that directly affect flight safety, and aviation authorities have also issued bulletins. The search for solutions to the situation that has become a severe problem for the industry has intensified. Therefore, the effects of the bird strikes have been tried to be minimized. ICAO's Safety Management System (SMS) is a reflection of the new generation paradigm that sees the world as it is, and proactive steps are taken in this system, such as precautions that must be taken before accidents and incidents occur, root causes that lead to accidents and serious

unsafe incidents. In this context, the proposed solution earlier, the newsletters published, and all the research in this direction are considered essential steps to increase the SMS success of the enterprises (ICAO, 2009, 2013).

When the history of the bird strike is examined, it is seen that events also left a mark on the history of aviation. One of the incidents which left a mark on history is US Airways flight 1549 on January 15, 2009. When the A320's engines ingested a flock of Canada geese and lost all power, the pilot had no option but to land in the cold Hudson River. (Wrigley, 2018). Considering the development of the bird strike events, they are not only events encountered in the recent past but, on the contrary, they date back to the early years of aviation. The event recorded by the Wright brothers in 1905 appears as the first written bird strike record (Coban & Bahar, 2018; Heimbs, 2011). In addition, a lot of data has been published containing statistical information on bird strikes.

Standards have been developed around the world about bird strikes and different solutions have been tried to be produced with effective risk management. States publishing information such as regions with a density of birds, migration routes, etc., in their Aviation Information Publications (AIP) and NOTAMs within the framework of ICAO standards can be considered examples of these solutions mentioned above. Radars are also used in the release of these NOTAMs. In addition, these publications are more specific under the name BIRDTAM. BIRDTAM includes possible bird strike risks, especially in low-level airspace. Risk levels are determined numerically from 0 to 8 according to the density of birds. The airport services manual (Doc 9137), Part 3 Wildlife Control and Reduction, Fourth edition, 2012, which ICAO published, was translated to Turkish by the Directorate General of Civil Aviation (SHGM, 2016). In the Airports Organization Services directive, under the Fight Against Wildlife and Birds title, the General Directorate of State Airports Authority (DHMI) stated that its goal is to gain, maintain and develop flight and ground safety (General Directorate of State Airports Authority, 2018). In addition, It is emphasized that this struggle is conducted in accordance with international standards. As it is known, it is essential to receive feedback from people, that is, to report it, to follow an interactive matter. For this reason, DHMI requests that systematical reports be published on cases or incidents related to bird strikes that the pilots will organize. These notifications are sent by DHMI to SHGM for evaluation and submission to ICAO within the scope of ICAO IBIS (Bird Strike Information System). Investigating the ecological structure on flight routes and around airports and taking precautions by following the activity intensities of birds according to the migration seasons are some of the crucial methods utilized to fight bird strikes (Cleary & Dickey., 2010). The following bullets can be shown as examples of precautions that can be followed against bird strikes around airports:

- It seems that habitat management stands out. For this reason, in order to prevent the concentration of bird flocks around airports or to distract them as far as possible, waste that may be a source of food for them should be placed in areas away from airports (Allan, 2000).
- In addition, precautions such as keeping trees that provide birds with shelter and food or water sources that they can drink, even for landscaping purposes, far away from airports should be taken seriously.
- Birds can be distracted with the help of devices that emit the sound of birds of prey which can be placed around the airport. The sounds at a frequency that the human ear cannot hear that causes birds to fly away can be considered in this context.
- Birds of prey or hunting dogs can be entangled against flocks of birds.
- It is recommended that light-reflecting objects be hung on the runway edges. (Those which do not adversely affect the flight crew and tower attendants)
- If there is no obligation, low-altitude flight planning should be done less; if it is otherwise, avoiding migration routes should be considered.
- Examples of fight against bird strikes include making the necessary warnings when intensive bird activities are detected using airport surveillance radar or established observation stations.

Some of the documents published by the aviation authorities of countries or international aviation organizations about wildlife or bird strikes are as follows (SKYbrary, 2022):

- ICAO Doc 9137: Airport Services Manual Part 3 - Wildlife Control and Reduction
- ICAO Electronic Bulletin: 2008 - 2015 Wildlife Strike Analyses
- Wildlife Control Procedures Manual, Transport Canada TP11500E (2002)
- Sharing the Skies Transport Canada TP 13549E second edition 2004
- UK CAA CAP 772 - Wildlife hazard management at aerodromes
- AC 150/5200-33B: Hazardous Wildlife Attractants on or Near Airports, FAA
- Wildlife Hazard Management at Airports FAA (2005)
- Airport Practice Note 6 'Managing bird strike risk', by the Australian Airport Association
- Bird strike, a European risk with local specificities GA (EASA, 2013).

The results of the bird strike analysis belonging to different countries were shared using open access resources within the scope of this study. The study aims to gather statistical data related to bird strikes from different countries to examine and compare them with bird strike events in Türkiye. As a result of the literature review, data on bird strikes belonging to some countries have not been reached. Some of the data on bird strikes are unavailable to reach because the civil aviation authorities in many countries have not shared their data, and the reporting by airline companies is insufficient. However, it is important that bird strikes belonging to pioneering states in aviation such as the United States, Great Britain and air traffic intensive states such as Türkiye are examined within the scope of this study in order to shed light on bird strikes in other states.

2. Materials and Methods

In this study, the comparison between Türkiye's and other selected countries' bird strike data has been made accordance with specific criteria. Accessibility of data was primarily

effective in determining the list of the countries. In this context, the selected countries and dates are given in Table 1.

Table 1. Countries in the Study

Country	Years	Data
Turkey	2015-2020	DGCA
USA	2000-2020	FAA
UK	2012-2016	CAA
Australia	2008-2017	ATSB AU
Finland	2000-2011	Finnish Transport Safety Agency
Iran	2000-2014	Iran CAA
Czechia	2011-2020	Czech DGCA
ICAO	2008-2015	ICAO

According to the data in Table 1, Türkiye has been compared with developed countries such as the USA, UK, Australia, and Finland. Also, other countries such as Iran and Czechia have been made. When looking at the data set, since historically, the same years cannot be obtained for all countries, the research was evaluated based on common years and total numbers. In order to obtain the data, the web pages of the countries' civil aviation authorities and the official reports published by them were used. After determining the countries and regions, the comparison years, and the data sources, information about the criteria is presented in Table 2.

Table 2. Criteria Used in the Study

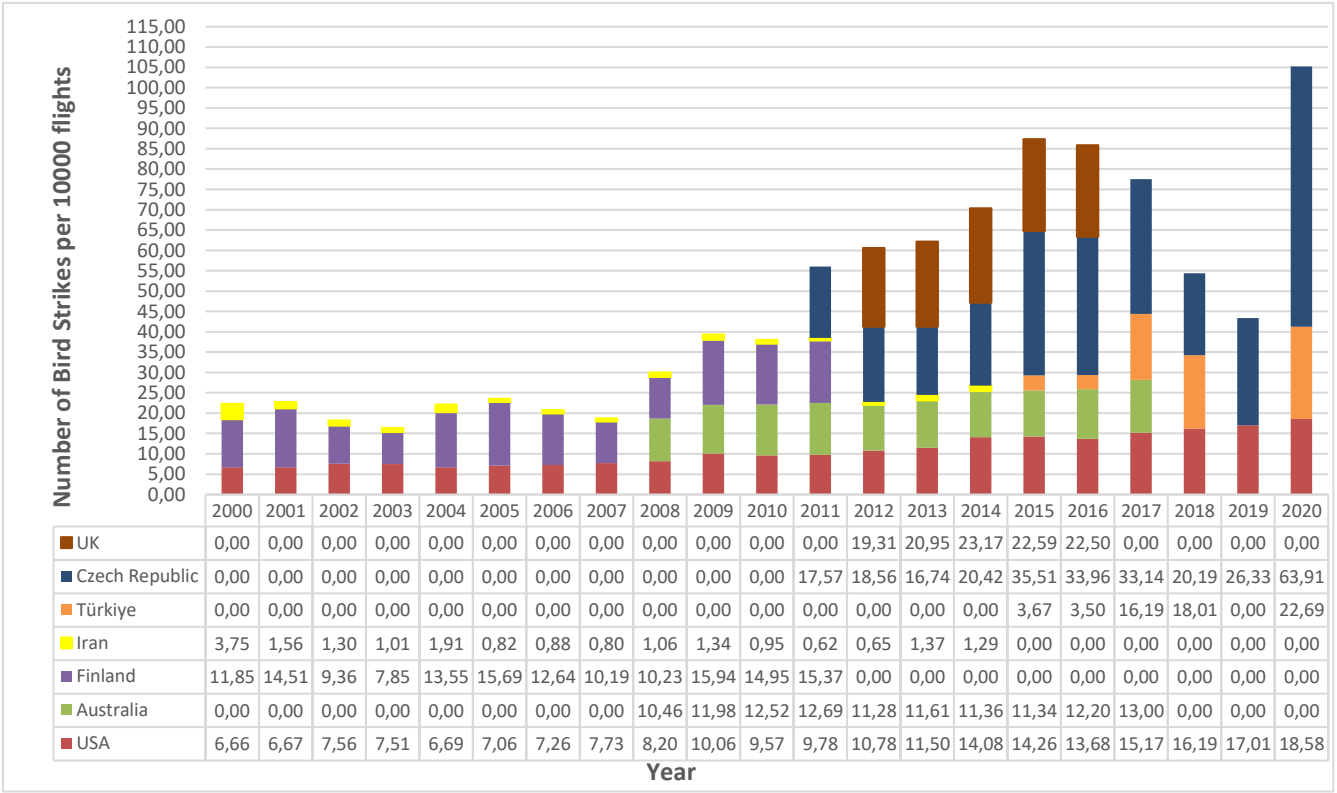
Comparison Criteria
Number of bird strikes per 10000 flights
Distribution by Months
Flight Phase
Aircraft Component
Time of the Day

According to Table 2, the criteria in this study are the data on bird strikes per 10000 flights, distribution of the number of birds strikes according to months, phases of flight, and the components hit by the birds. Finally, the time of the event occurred on a day.

In order to obtain the data of bird strike incidents occurring in every 10,000 flights, one of the criteria determined in the research, the total number of flights on a yearly basis, and the total bird strike incident data were converted into proportional data. Then, the number of bird strikes was arranged as per 10000 flights on the basis of countries. The reason for that is to make a more valid and reliable comparison since the numbers of flights between countries are different. It is quite natural that more incidents occur in a country with more flights than in those with a smaller number of flights. For this reason, as mentioned earlier, one can consider that a proportional comparison of the data will give more relevant results.

3. Findings

In this study, bird strike data occurring in USA, UK, Czech Republic, Türkiye, Iran, Finland and Australia were examined (Australian Transport Safety Bureau, 2019; CAA, n.d.; Dogan, 2019; FAA, 2021; Juračka et al., 2021; Nikolajeff, 2014; SHGM, 2020; Zadegan & Rezaiefar, 2016). It is considered that a more proper comparison requires bird strike numbers on 10 000 flights due to the fact that the annual flight numbers of aircraft belonging to certain countries differ. In this context, bird strike rates in 10 000 flights belonging to certain countries as a result of the investigations are shown in Figure 1.



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
UK	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	19,31	20,95	23,17	22,59	22,50	0,00	0,00	0,00	0,00
Czech Republic	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	17,57	18,56	16,74	20,42	35,51	33,96	33,14	20,19	26,33	63,91
Türkiye	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	3,67	3,50	16,19	18,01	0,00	22,69
Iran	3,75	1,56	1,30	1,01	1,91	0,82	0,88	0,80	1,06	1,34	0,95	0,62	0,65	1,37	1,29	0,00	0,00	0,00	0,00	0,00	0,00
Finland	11,85	14,51	9,36	7,85	13,55	15,69	12,64	10,19	10,23	15,94	14,95	15,37	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Australia	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	10,46	11,98	12,52	12,69	11,28	11,61	11,36	11,34	12,20	13,00	0,00	0,00	0,00
USA	6,66	6,67	7,56	7,51	6,69	7,06	7,26	7,73	8,20	10,06	9,57	9,78	10,78	11,50	14,08	14,26	13,68	15,17	16,19	17,01	18,58

Figure 1. Number of bird strikes per 10000 flights by country between 2000 and 2020

In the data shown in Figure 1, 0 indicates no data on bird strikes for that year belonging to the specified countries. When Figure 1 was examined, it is clear that there was a serious increase in bird strike rates in Türkiye in the following years compared to 2015 and 2016. It is considered that the fact that the reporting event has been conducted electronically since

2017 is an important factor in this increase. In this context, one can say that the data of Türkiye before 2017 are not very reliable (Dogan, 2019). When looking at the United States, which has shared its data for all years, it can be observed that bird impact rates on 10,000 flights tend to increase overall compared to the years, and the data for 2020 are about three times higher compared to 2000. The FAA, the aviation in the United States, declares that as of 2012, according to FAA directive JO 7210.632, Air Traffic Organization (ATO) personnel must report all bird strikes that they have become aware of. In this context, it is normal for the numbers to be higher in 2012 and later years (FAA, 2021).

When one looks at Finland, Australia, Iran, and the United Kingdom, it is understood that bird strike rates show a uniform distribution as a whole in accordance with the years. For Iran, these rates are low because the total number of bird strikes in the 15-year period between 2000 and 2014 is 242, which is a very small number. While this number is 1392 in Türkiye in 2018 alone, it is a great value for the United States of America as 15998 in 2018.

There are many factors that affect bird strike rates. The presence of birds in the area of airports, the time period of the flights (Day and Night, etc.), the months in which aircraft are flying, the precautions taken to reduce bird strikes at airports or flight routes, and the types of birds near airports, are some of the data in an effective reporting must include. Figure 2 shows the distribution of bird strikes by month.

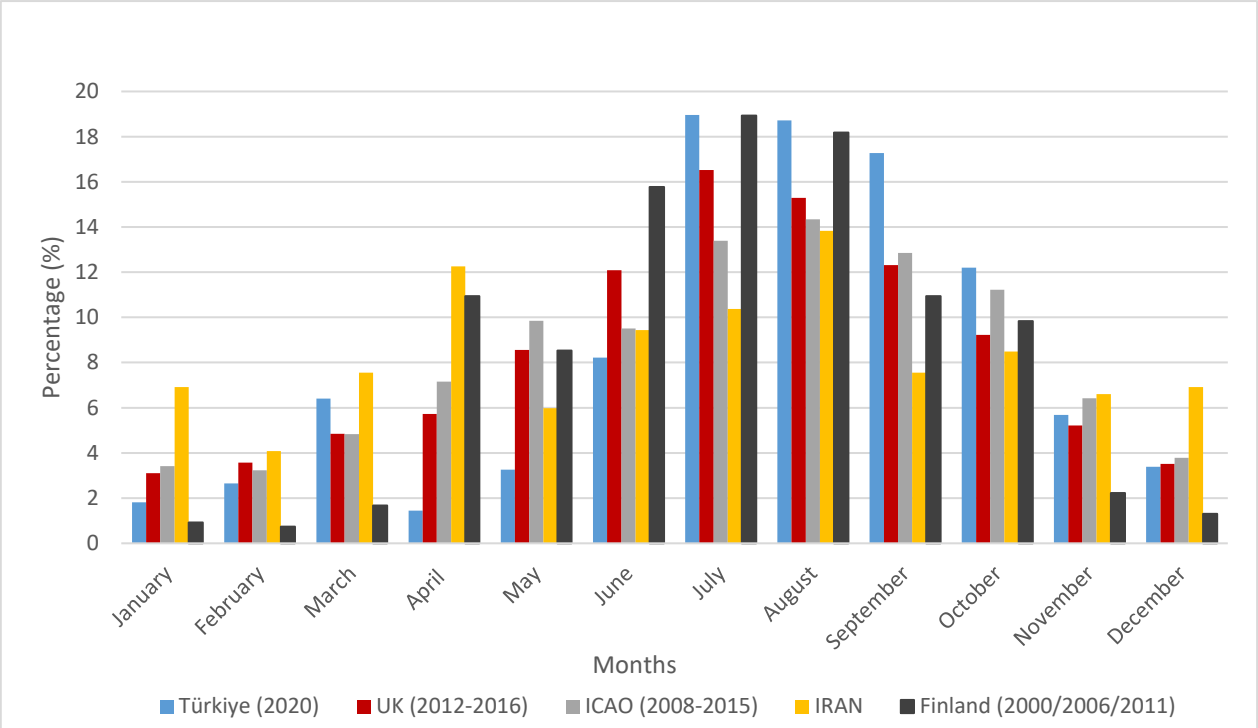


Figure 2. Bird strikes as a percentage by month

Figure 2 shows more bird strikes occur in summer. The number of flights and the greater density in the mobility of birds in these months are considered to be important reasons. As a matter of fact, in states such as Türkiye, where tourism takes an important role in the country's economy, there is a serious increase in the number of flights in the summer. In addition, people going to different countries for tourism often prefer air transportation due to the advantages such as speed, safety, and comfort provided by airline companies for their customers. As a result of this preference, the number of flights in the summer also increases.

Figure 2 shows the ICAO bird strike data by month between 2008 and 2015 separately. Currently, despite the fact that the number member states of ICAO is 193, there have been reports by only 91 states. Although there is no bird strike data for all states, according to the ICAO data, which collects data from different countries from different continents under one roof, one can understand that attention should be paid to bird strike events, especially in summer.

In Figures 3-6, bird strike data were shared according to the flight phase. A regular flight operation usually consists of take-off, climb, cruise, approach, and landing stages, respectively.

According to the flight phase for Türkiye between 2017 and 2018, one can observe that approximately 95-96% of the strikes occur during the take-off, approach, and landing phases. The high bird strike rates in the take-off and landing flight profiles near the airport show the importance of taking precautions around the airport. Figures 3 and 4 show that the case of a taxi in which the aircraft is located at the airport, parking position, and a cruise flight have relatively low strike rates. Factors such as the fact that the temperature and oxygen content is relatively low at the altitudes where today's commercial air transport aircraft fly reduce the likelihood of encountering a flock of birds at these altitudes. In this context, it is normal for the number of strikes to be so low on a cruise flight.

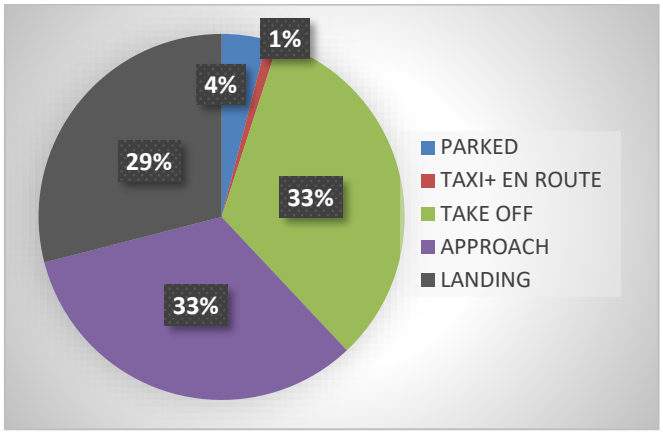


Figure 3. Bird strike by flight phase in Türkiye 2017

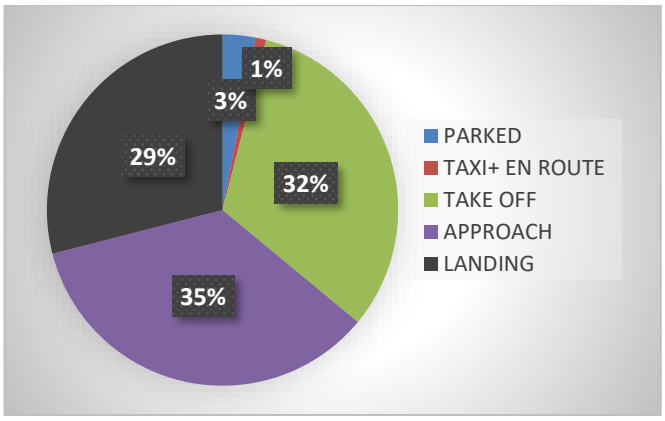


Figure 4. Bird strike by flight phase in Türkiye 2018

The bird strikes in Finland according to the flight stage in three different years show that the vast majority of the collisions occurred during the take-off, climb, approach, and landing stages where the flight altitude is low, which is parallel to the Türkiye's data. The approach stage has a considerable share of bird strikes, such as 46%, and this rate corresponds to the data of Türkiye, as well. However, it differs from the Turkish data by the fact that the cruise stage has an 8% rate. It is believed that the high output of data for the cruise stage is since helicopters, piston-engined, and turboprop aircraft, in which the cruising altitude is relatively lower than commercial passenger-carrying aircraft, are also included in the statistical data.

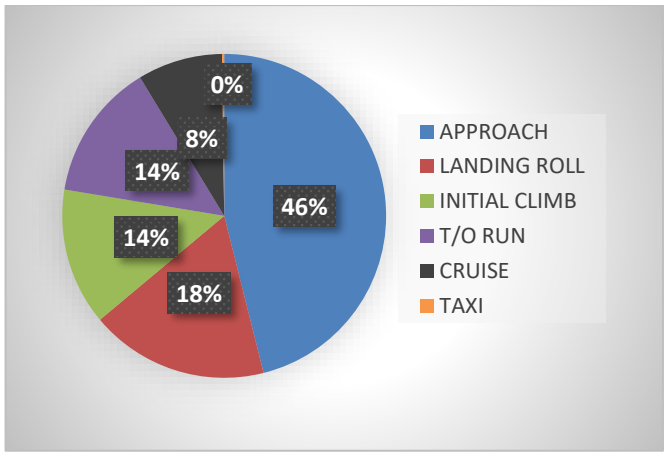


Figure 5. Bird strike by flight phase in Finland 2000/2006/2011

According to the ICAO data, the flight profile with the highest number of collisions is the approach stage with 35%, followed by the takeoff stage with 33% and the landing stage with 27%. In parallel with the data of other countries, it can be said in the ICAO data that these three flight stages account for a high percentage of all collisions.

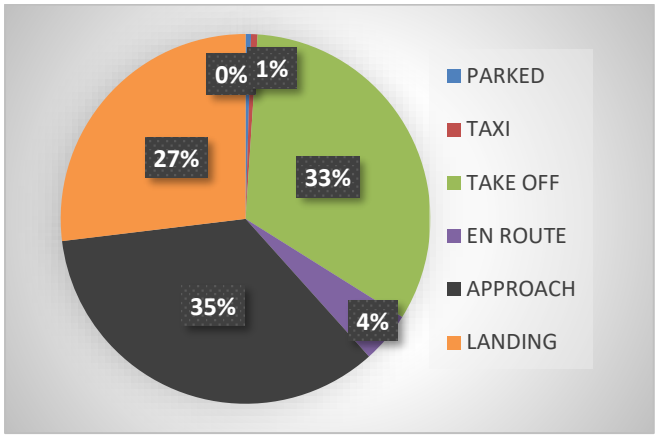


Figure 6. Bird strike by flight phase ICAO 2008-2015

Figure 7 shows the components damaged as a result of bird strikes. Only Iran and ICAO data are shared in Figure 7 because only data belonging to this country/authority can be accessed. When the specified figure is examined, it is seen that radome/nose and windshield are the two critical components exposed to collisions with 27% and 15% in the ICAO data. The presence of both aircraft sections at the front of the aircraft indicates that the collisions were mostly caused by oncoming birds. Again, according to ICAO data, engines were subjected to collisions by 14%. It is understandable for data to be high due to the high density of sucking air from aircraft engines. In the Iranian data, it can be again observed that aircraft engines have the largest share with 16%. The fact that a considerable percentage, such as 52%, is not known for Iran shows that reporting is not being applied very effectively.

The fact that bird strikes cause damage to aircraft components exposes airline companies to significant costs. In 2017, the cost of bird strike-induced maintenance in Türkiye was $33.08 million. For 2018, this value corresponds to a figure as high as 45.18 million dollars (Dogan, 2019). In addition to the maintenance costs, it is important to minimize the risks associated with bird strikes due to injuries to passengers and crew, plane accidents, cost increases caused by the inability of damaged aircraft to make scheduled flights, and customer dissatisfaction because of canceled flights.

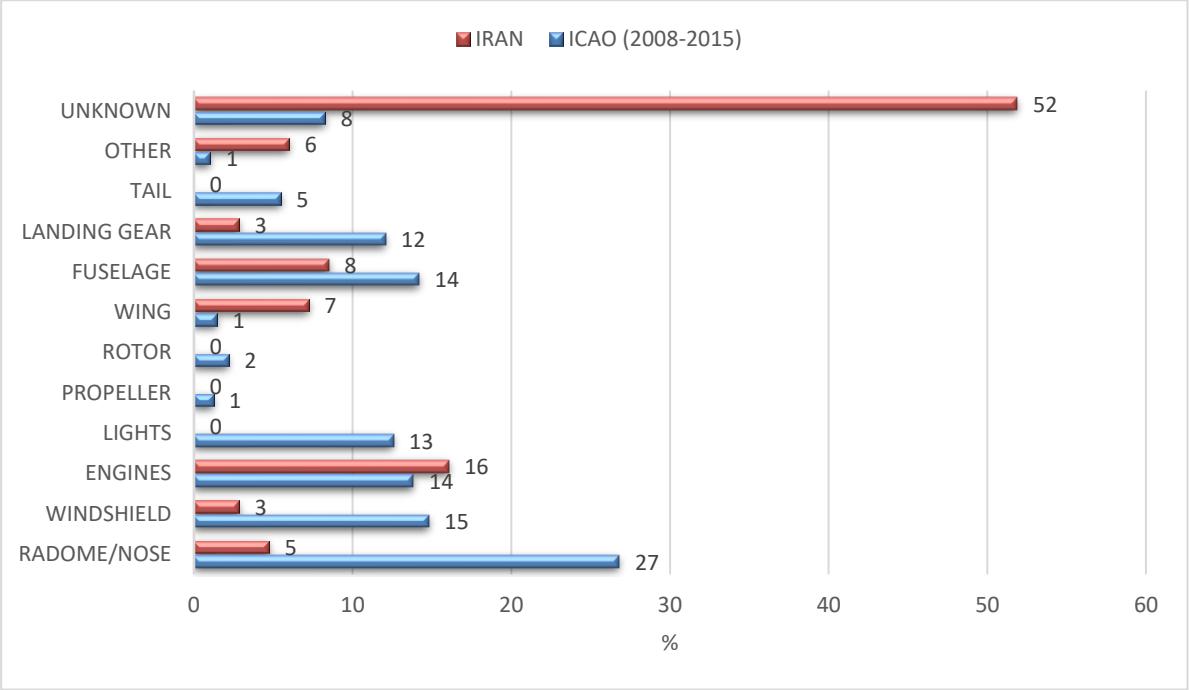


Figure 7. Aircraft parts damaged by bird strike

Within the scope of the study, bird strike percentages in different time periods were finally examined. As one can see in Figure 8, it is clear that bird strike rates are quite high during daytime, when the number of flights is greater. This is followed by nighttime with 24.56% (ICAO) and 17.68% (USA).

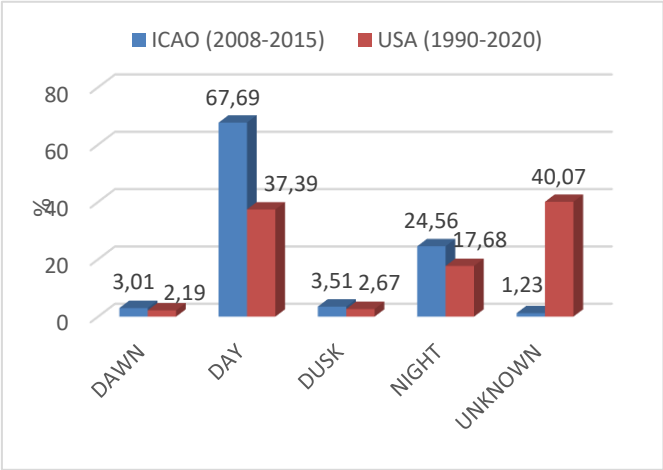


Figure 8. Bird strike by time

4. Discussion and Conclusions

Air transport connects continents, countries, regions with a unique global transport network, allowing people, cargo or mail to be relocated from place to place much faster than other modes of transport. In addition, it produces a tremendous amount of labor force directly or indirectly throughout the world. For these reasons, the air transport industry plays a very important role in increasing economic processes, social development and global prosperity throughout the world (ATAG, 2008; Wensveen, 2007). In order to obtain these benefits, air transport activities must be carried out safely. When this does not happen, unwanted results caused by safety matters may occur. As a result, accidents, incidents, injuries, or even deaths may occur (Gerede and Yaşar, 2017). Flight safety is extremely threatened when birds, which are often encountered in the sky where the aircraft perform their navigation, crash into aircraft, especially during the landing and take-off stages. When these collisions are explicitly exposed to the power group of the aircraft, the grip on the air becomes difficult, forcing aircraft into emergency landings, as occurred in the famous example Sully. In this regard, birds in some cases may present problems with the provision of the above-mentioned aviation safety. This study gathered statistical data on bird strike events from certain countries and Türkiye to examine and compare these data and offers a descriptive presentation for the readers.

The data shows that the bird strike rate on 10 000 flights has increased in countries such as Türkiye and America in recent years. On the basis of this, it was concluded that the share of increased air traffic and more effective reporting is high. In addition, although the precautions against bird strikes have been taken densely in recent years, the cost dimension of approximately $78.26 million in damage for Türkiye between 2017 and 2018 shows that more work should be done to minimize bird strike rates. Even though each of the countries under this study is in different geographies and has different bird species, there are similarities in the time periods, months, and flight phases where the bird strikes occur the most. This gives the idea that standard precautions can be taken to combat bird strikes to obtain a better safety report card in this matter.

When the data obtained from various sources are evaluated, it is understood that bird strikes are an important safety problem and a priority of risk management. As one can see through the events or cases, the responsibility falls on humanity since birds cannot take precautions against collisions. As a result, it is evident that compliance with the published and updated standards using experience is not an option but a must; otherwise, incidents/accidents that will

cause material damage or loss of lives are inevitable. In addition, to minimize the damage caused by bird strikes that occurred in the aviation industry, one of the world's most organized and standardized industries, the national aviation authorities of the states must report the cases in an organized and systematic way. Another recommendation from this study is that data on bird strikes must be systematically collected by all countries' aviation authorities and reported to an international organization such as ICAO within specific time frames. Thus, it is thought that modeling via data analysis can guide professionals on a problem-solving path. Another situation that may make a significant contribution here will be the provision of bird strike committees or working groups established by some countries to be also found by other countries.

Today, it is observed that countries use various methods in combating bird strike. One of them is bird observation radars. Bird-watching radars are used to monitor birds. Hatay airport is the first airport in Turkiye to have a bird observation radar system (gokyuzuhaberci.com, 2011). 95% of the major airports in Spain use falcons, which are birds of prey, to prevent bird strikes. At Madrid's Barajas airport, falcons are trained to patrol its runways. There is a 'fleet' of 70 Peregrine falcons based at this airport (theolivepress.es, 2022). Advanced technology is used in the fight against birds in Canada. Edmonton International Airport is one of the first airport examples in the world to use robotic falcons to chase birds out of their flight paths and block nearby nesting sites (cbc.ca, 2017). In the legal regulations related to bird strike, there are issues related to how the designs of aircraft should be in case of a possible collision. For instance, the FAA, in its regulations on aircraft suitability, stated that the aircraft should be designed to ensure the ability of the aircraft to continuously safe flight and landing after a collision with an 8-pound bird (FAA, 1970).

Ethical approval

Not applicable.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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