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Research Article

Taxonomic spectrum of birds, settlement character, and assessment of collision risk with aircraft during the breeding season at Heydar Aliyev International Airport

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Abstract

Between 2022 and 2024, 26 bird species belonging to 8 orders, 18 families, and 14 genera that pose a threat to aircraft during the breeding season were identified at Heydar Aliyev International Airport. Based on their settlement characteristics within the airport area, 15 species from 4 orders, 10 families, and 13 genera were classified as resident populations, while 11 species from 4 orders, 8 families, and 11 genera were classified as migratory-nesting populations. The probability of bird-aircraft collisions was assessed: 5 species scored between 0-20 points, 8 species between 20-40 points, 1 species between 40-60 points, 4 species between 60-80 points, and 8 species between 80-100 points.

Keywords: aircraft, hazard, reproduction, settlement, collision

Introduction

The increasing speed and operational intensity of aircraft, which are among the primary and fastest modes of transportation worldwide, heighten the probability of bird-aircraft collisions. Beyond their economic impact, these collisions pose a significant safety concern due to the potential for large-scale human casualties. The high-pressure air intake of turbofan engines, which absorb large volumes of air (with fan blades rotating at speeds ranging from 10,000 to 12,000 rpm per minute), can draw birds into the engines, causing severe damage to valuable aviation technology (Jakobi, 1986). In addition to engine failures, bird strikes can also damage

aircraft windshields, wings, fuselage, and other critical components. Studies have shown that a bird the size of a seagull, when colliding with an aircraft traveling at 320 km/h, exerts a force of 3,200 kg, while at 960 km/h, the impact force increases to 28,800 kg (Jakobi, 1986). To mitigate the risks of bird strikes at airports, it is essential to study the bioecological characteristics of hazardous bird species. In this regard, installing radar systems at airports enables monitoring of migratory routes, flight altitudes, speeds, and whether birds fly alone or in flocks (Jakobi, 1974). By utilizing radar technology, it is possible to identify new patterns in bird orientation and navigation, allowing for preventive measures and forecasting potential hazards (Casidy, 1967). Understanding the orientation and navigation behaviors of both resident and migratory-nesting birds that pose risks to flight operations can help mitigate potential dangers and prevent large-scale human casualties. Heydar Aliyev International Airport is located in Bina settlement, 20.0 km northeast of Baku, and is the largest international airport in the Caucasus region. The airport covers a total area of 1,565.7 hectares and has a perimeter of approximately 27.0 km. It is secured by an electronic fence and is equipped to accommodate A, B, C, D, and E category aircraft as well as all types of helicopters. The airport is situated 2.0 km from the Caspian Sea. The presence of numerous large and small lakes near the Absheron Peninsula, close to the airport's boundaries, increases the likelihood of bird-aircraft collisions during local bird movements. The airport has two runways with asphalt-concrete surfaces, measuring 3.2 km and 4.0 km in length. To enhance flight safety, MK-III devices and sound amplifiers manufactured in Canada are installed on both sides of the 3.2 km runway (Fig. 1). Specifically, seven sets of bird deterrent devices and 42 sound amplifiers are positioned along the shorter runway, while the 4.0 km runway is equipped with 12 sets of deterrent devices and 72 sound amplifiers.

Figure 1. Sound Amplifier of the MK-III Device, Manufactured in Canada.

Each control unit manages six sound amplifiers, with each amplifier having a sound propagation radius of 750.0 meters. The distance between the two control units is 900.0 meters, while the spacing between individual sound amplifiers is 300.0 meters (Jakobi, 1974). These devices function at specific intervals by emitting predator calls and other artificially generated deterrent sounds to keep birds away from the runways (Fig. 2). However, their effectiveness on birds that have been settled in the airport area for a long time is minimal. They have a partial impact on migratory-nesting species that temporarily and briefly settle in the area along migration routes.

Figure 2. Brain (Kit) of the MK-III Device, Manufactured in Canada.

The frequency of bird-aircraft collisions in Azerbaijan's airspace varies depending on the country's natural and geographical conditions, the location of airports, and seasonal factors. Heydar Aliyev International Airport, situated on the Absheron Peninsula, lies directly along the bird migration routes from north to south and west to east, classifying it as a high-risk zone. Each year, hundreds of thousands of birds migrating from Southeast Asia and Africa pass through the airport area during their breeding season, posing a significant threat to aircraft (Qadirzade, Taghiyev, 2024a, b). During the breeding season (May, June, and July), the substantial increase in airport flight activity further escalates the potential risk of collisions. Unfortunately, despite the rising global damage caused by bird strikes, essential steps toward developing and testing modern mitigation methods have not been adequately implemented. To minimize the frequency of bird strikes, wildlife management strategies within and around the airport must be developed using advanced methods. Investigating bird strikes and managing associated risks is crucial for assessing and predicting potential hazards.

Material and methods

Between 2022 and 2024, field studies were conducted at Heydar Aliyev International Airport during the spring and summer months (April, May, June, July, and August). Surveys were carried out using both pedestrian and vehicle-based observation (at speeds of 20–30 km/h) from 06:00 to 19:00. The research focused on different ecological groups of resident and migratory-nesting birds, examining their species composition, settlement patterns, population numbers, and the specific species posing a threat to aviation. The likelihood of bird strikes was assessed using a 100-point scale:

- 0–20 points (low probability)
- 20–40 points (moderate probability)
- 40–60 points (considerable probability)
- 60–80 points (high probability)
- 80–100 points (very high probability)

The evaluation was based on airport statistical data and the bioecological characteristics of bird species that pose a threat to aircraft. Additionally, natural and anthropogenic factors influencing resident and migratory-nesting birds in the airport area were considered in assessing their hazard levels. The study also analyzed food resource availability, the quantity and quality of food objects, and the accessibility of food sources for different bird populations within the airport area. These factors were examined to determine their role in attracting birds and influencing the risk of bird strikes.

Results

During this period, both resident and migratory-nesting species found at Heydar Aliyev International Airport belong to the following orders: Ciconiformes, Falconiformes, Charadriiformes, Columbiformes, Strigiformes, and Passeriformes. Statistical data from the breeding season, collected through pilot reports and observations of bird carcasses on runways, indicate that most bird strikes occur at altitudes of 0–300 meters during aircraft takeoff and landing.

On April 13, 2024, a flock of 17–20 individuals of Plegadis falcinellus (glossy ibis) was recorded in a wetland area covered with *Paspalum digitaria* Poir. grass, adjacent to the airport's electronic fence. This biotope is not characteristic of the airport or its surrounding areas. In Azerbaijan, this species is exclusively part of the migratory-nesting population and is observed only during the breeding season, with no records outside this period. During migration, these birds use the area as a temporary resting site, typically flying at altitudes of 50–100 meters over short distances. Due to their flock-based movement, body mass (530–800 g), straight-line flight trajectory, and weak maneuverability in the air, they are considered a high-risk species for bird strikes. However, their collision probability is rated at 20–40 points on the 100-point scale. This relatively low score is due to the species' low overall population in Azerbaijan and its rare presence in the wetland areas near the airport and surrounding anthropogenic landscapes. Consequently, during the three-year study period (2022–2024), this species was recorded in the airport area only once.

A single individual of *Ardea purpurea* (purple heron) was observed in a reed-willow swamp within the airport area on April 9, 2023, and April 7, 2024. The species exhibits variable flight altitudes during long-distance and local movements. While it is commonly found in the numerous lakes of the Absheron Peninsula, its recorded flight altitude in the airport area during observations was 50–100 meters. Purple herons typically settle solitarily. During local movements, their flight follows a straight trajectory with moderate speed, and their maneuverability to avoid collisions is weak. The likelihood of encountering this species in the area is low due to the high presence of disturbing anthropic and anthropogenic factors in the lakes near the airport and along the Caspian Sea coastline. Because of the species' low population density, solitary nature, and the airport area's inability to fully meet its trophic and biotopic requirements, its bird strike risk is rated at 0–20 points on the 100-point scale (Fig. 3).

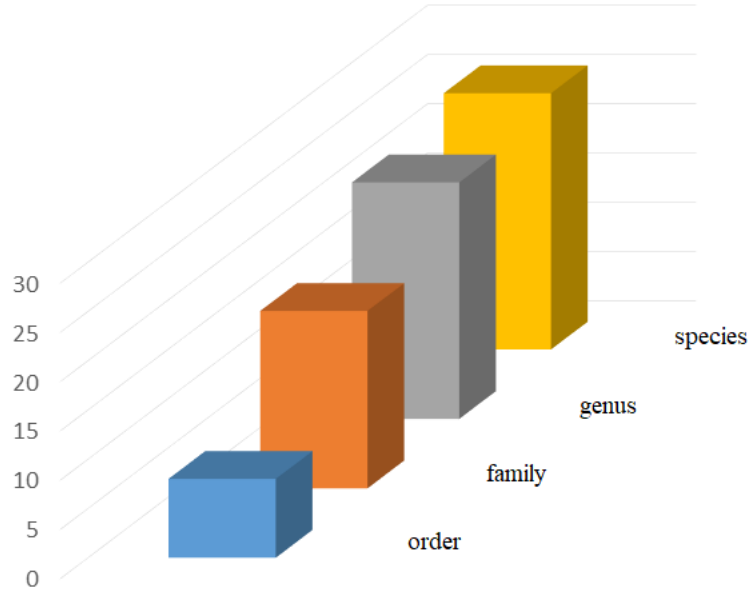

Figure 3. Taxonomic spectrum of birds during the breeding period at Heydar Aliyev International Airport.

Falco tinnunculus (common kestrel) is a resident species of the Falconiformes order, with a population of 3-5 individuals in the airport area during the reproduction period. The kestrels search for food mainly at heights of 20-50 meters. Although they have high maneuverability to avoid collisions with aircraft while flying, collisions with aircraft occur frequently, as evidenced by pilot reports and the discovery of deceased individuals on the runway. The high collision intensity (80-100 points) is attributed to their hunting behavior, where they hover in the air like a "pendant" and dive to catch prey. Circus aeruginosus (marsh harrier), another resident species of Falconiformes, is highly dependent on its habitat but often makes frequent flights near the runway areas in pursuit of food. It has high maneuverability to avoid collisions with aircraft. Its flight altitude generally ranges from 20-50 meters, and considering that it rarely moves far from its settled habitat, the collision probability is rated at 20-40 points. For the *Himantopus himantopus* (black-winged stilt), a migratory breeding species of Charadriiformes, three individuals have been recorded in small ponds and reed-bush swamps within the airport area. This species has poor maneuverability in flight, and its straight flight trajectory makes it difficult to avoid collisions with aircraft. Given the species' low numbers of migratory breeding individuals in the country, its strong habitat specificity, and the weak trophic and biotopic connections within the airport area, the collision probability is rated at 20-40 points. Avian Species and Collision Risk at the Airport Area. Calandrella brachydactyla (short-toed lark) is observed in small groups within the airport area, predominantly in grasslands and areas with various herbaceous plants. Its flight altitude varies from 10 to 100 meters. Given its flight

patterns and frequent presence in areas where aircraft operate, the collision intensity is rated high at 80-100 points. *Galerida cristata* (crested lark) and *Melanocorypha calandra* (Calandra lark) both inhabit grasslands and herbaceous biotopes near the runway. They are observed in small groups or occasionally in flocks. Their flight height ranges from 20 to 100 meters. Both species engage in chaotic flights near the runway as they forage. Due to their frequent flying patterns and proximity to aircraft pathways, the collision probability is rated at 80-100 points. During the reproduction period, several species of Larus (gulls), including *Larus ichthaetus* (Great black-headed Gull), *Larus cachinnas* (Caspian Gul), *and Larus sp*., are observed in reedy and swampy biotopes, small ponds, and areas close to the airport's perimeter fence, such as landfills and sewage channels. Throughout the research years, it was noted that the gulls often fly over the runway, especially when foraging at landfills and sewage areas. Additionally, during high winds (over 20-25 m/s), the number of gulls arriving from the Caspian Sea increases. Although these gulls can maneuver well, their flight patterns become much less controlled in flocks, significantly increasing the risk of collisions. The collision probability for gull species is rated at 80-100 points based on the frequency of their encounters with aircraft, primarily occurring at altitudes of 50-100 meters. Columba livia (rock dove), from the order Columbiformes, is observed frequently in the spring and summer months near the airport, particularly in areas around the National Aviation Academy's administrative buildings. These pigeons frequently fly into the airport to forage, especially during daylight hours. They are commonly seen flying near grassy areas, fruit trees (mulberry, fig, cherry, jujube, olive, quince), and pine trees. The primary collision risk for this species occurs during their rapid flights over the runway. Although the airport's ornithologists and hunters attempt to disperse them by firing into the air, the pigeons often return within 3-5 minutes. These pigeons, generally in groups of 3-8 individuals, are observed flying at 50-100 meters altitude over the runway, often due to their need to feed their young during the breeding season. This behavior increases their collision risk with aircraft, with the collision probability rated at 80-100 points. *Spilopelia senegalensis* (laughing dove) has been observed in the airport area, particularly in regions with pine trees. While sightings are rare, the high population density on the Absheron Peninsula and abundant food resources in the area increase the potential for aircraft collisions, with the collision probability rated at 40-60 points. *Athene noctua* (little owl) from the Strigiformes order has been observed near settlements close to the airport, particularly during early morning and dusk hours. The species is rare, and although it is a nocturnal bird, there was a recorded collision in 2024. The low population size and habitat specificity result in a relatively low collision risk, rated at 20-40 points. From the Caprimulgiformes order, *Apus apus* (common swift) and *Apus*

melba (Alpine swift) are observed frequently in the airport area during their breeding season. These birds typically fly at altitudes ranging from several meters to 100-200 meters, depending on weather conditions. They forage in the air and spend much of the daytime flying. Both species are characterized by rapid flight and strong maneuverability. Despite their agility, frequent collisions with aircraft have been noted for both species, with a collision intensity of 60-80 points for each (Fig. 4).

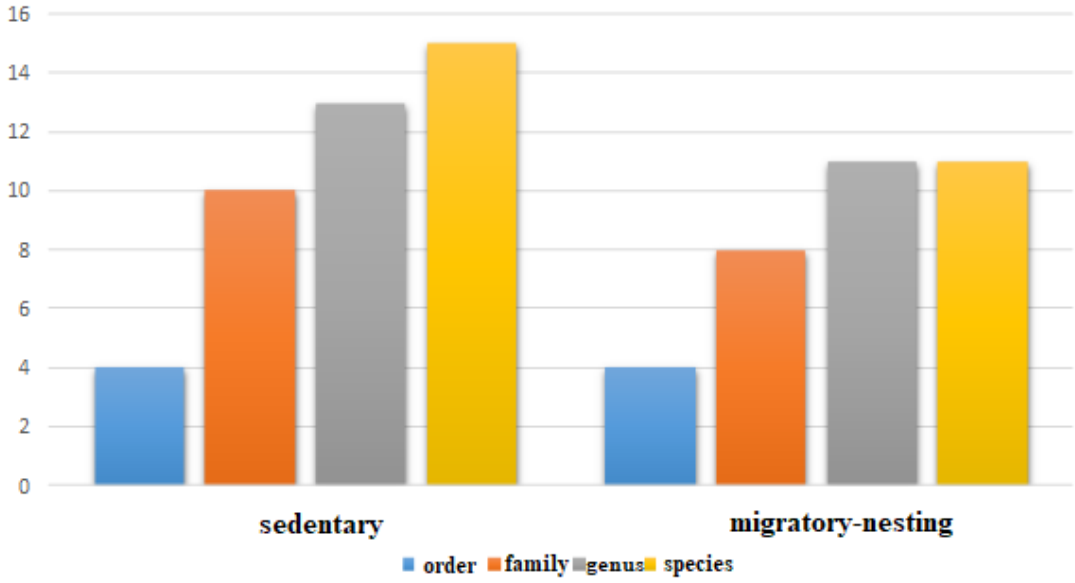

Figure 4. Settlement characteristics of birds during the breeding period at Heydar Aliyev International Airport

Merops persicus (Blue-cheeked bee-eater), from the Coraciiformes order, is a migratory-breeding species observed during the breeding season. In the research years, only 2 individuals were recorded. They were observed in reed and reedbed wetland areas located slightly away from the runway and near the boundary of settlements. Given the low population and strong maneuverability in the air, the collision risk for this species is relatively low, rated at 20-40 points. *Upupa epops* (Eurasian hoopoe), another member of the same order, was observed only once during the research period. With their low population numbers and tendency to spend much of their time foraging on the ground, the collision risk for this species is minimal, rated at 0-20 points. From the Passeriformes order, *Hirundo rustica* (barn swallow) and *Delichon urbicum* (Northern house martin) are commonly found in the airport area. These birds fly at various heights, depending on the weather conditions, and spend much of their daytime foraging in the air. Frequent collisions with aircraft have been recorded, with a collision risk rated at 60-80 points for both species. *Galerida cristata* (crested lark) and *Melanocorypha calandra* (Calandra lark), also from the Passeriformes order, are present in large numbers and pose a real collision risk. They are often observed in small groups, sometimes in flocks, foraging on the

ground, though they are also frequently observed flying in the air. Their collision probability is high, rated at 80-100 points, as they are commonly seen in the airport's various biotopes, except for saline areas. *Motacilla alba* (white wagtail), from the Passeriformes order, is found near grassy areas, various herbaceous plants, and fruit trees (such as mulberry, fig, cherry, jujube, olive, and quince) near the airport's runway. They are typically observed individually or in pairs, with flight altitudes ranging from 3-5 meters to 20-50 meters. As they are more ground-bound, they are less frequently seen in the air, and their high maneuverability in flight results in a low collision risk with aircraft, rated at 0-20 points. *Sturnus vulgaris* (starling), a species with high population numbers, is commonly found in areas near the runway, including grassy fields, fruit trees, and areas with shrubs. They tend to form large flocks (ranging from 400-500 individuals or more), and their complex aerial maneuvers increase the collision risk significantly. This species presents a real collision risk, rated at 80-100 points. *Pastor roseus* (rosy starling), which was recorded in 2023, typically forages on fruit trees such as mulberry, fig, cherry, and jujube, which are located around the airport's administrative buildings. While the species is found in flocks, its limited nesting opportunities in the area result in a moderate collision risk, rated at 20-40 points. *Corvus cornix* (hooded crow) is abundant during the breeding season and is found in both natural and disturbed areas, including the airport's biotopes. This species is known for its keen sense of danger and ability to evade threats. They are usually observed in small groups of 3-5 individuals, flying at altitudes of 10-100 meters. The collision risk is rated at 20-40 points due to their ability to sense and avoid danger.

Turdus merula (Eurasian blackbird), from the Passeriformes order, has a low population and is highly dependent on its specific biotope. Due to these characteristics and other bio-ecological traits, the collision risk with aircraft is minimal, rated at 0-20 points. *Passer domesticus* (house sparrow) is more associated with residential buildings, especially along the electronic fence of the airport. They spend most of their active daylight hours foraging on the ground, near the buildings. Given this ground-foraging behavior and their association with human settlements, the collision risk with aircraft is low, rated at 0-20 points. *Passer montanus* (Eurasian tree sparrow) is recorded in almost all natural biotopes in the airport area. They are observed individually, in pairs, in small groups, and occasionally in flocks. Their flight altitudes range from 5 to 50 meters, and they are more often seen in their natural biotopes compared to house sparrows. As they spend much of the daylight hours foraging on the ground, their collision risk with aircraft is rated at 20-40 points.

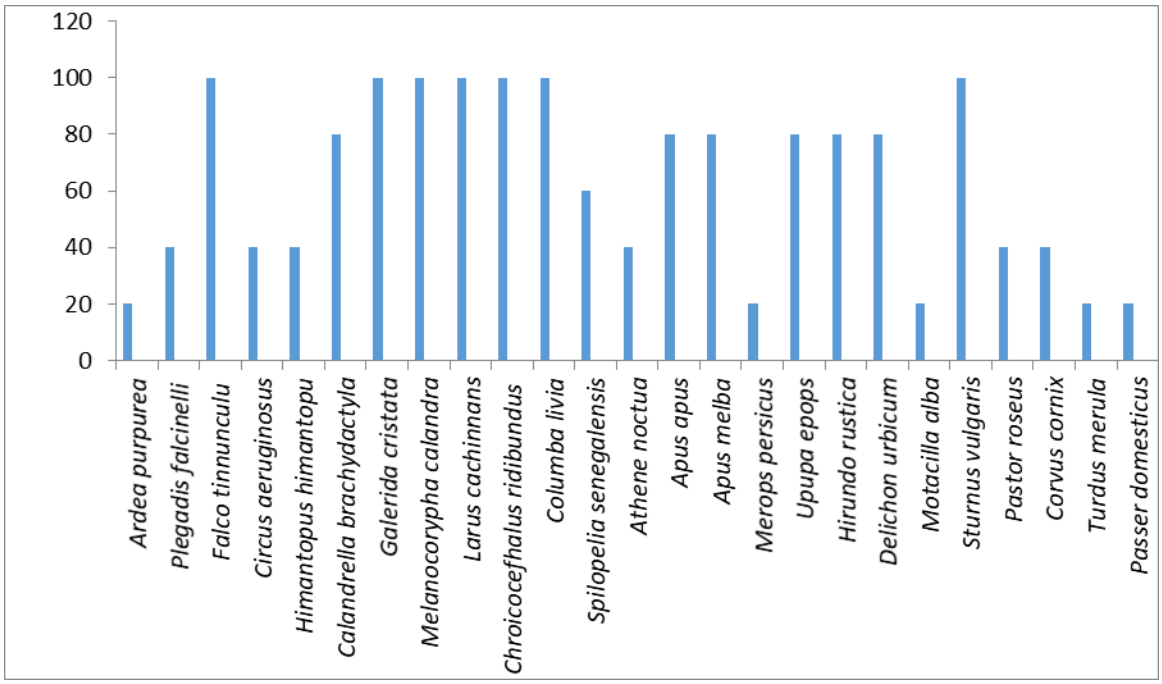

Figure 5. Assessment of the probability of bird collisions with aircraft at Heydar Aliyev International Airport (based on a 100-point system).
**Note: The intensity of collision probability - 0-20, 20-40, 40-60, 60-80,

Disscussion

Migratory-nesting bird populations from Southeast Asia and Africa pass through Azerbaijan while migrating northward. The primary migration route for birds crossing the Caspian Sea runs through the Absheron Peninsula, which extends 60–70 km into the Caspian (Mustafayev, 2003; Mustafayev, Sadigova, 2005). As migratory-nesting birds pass through the airport located on the Absheron Peninsula, they may settle in the area for short or extended periods. In addition to these migratory-nesting species, sedentary birds characteristic of the region also settle in the area for a long time. Bird strikes involving aircraft vary depending on the airport's natural and geographical conditions and the season of the year. Considering that birds are closely tied to specific biotopes during the breeding season, it is essential to identify the taxonomic spectrum of species that are on the migration route, using the area for foraging, and nesting in the airport area (Mustafayev, Sadigova, 2005, 2010). During the birds' breeding season (May, June, July), the simultaneous increase in flight intensity and the number of migratory-nesting birds at the airport significantly elevates the risk of serious hazards. Unfortunately, despite the growing global damage caused by bird strikes each year, essential steps toward the development and experimental implementation of modern methods to reduce bird strikes within airport territories is not adequately pursued. Research on bird-aircraft collisions and the management of associated risks is crucial for forecasting the severity of such incidents and minimizing their impact (Qadirzade, Taghiyev, 2024 a, b).

Conclusion

Heydar Aliyev International Airport is considered a high-risk area due to its location along a major bird migration route, making bird-aircraft collisions a serious safety concern. During the breeding season, the likelihood of collisions involving sedentory and migratory-nesting bird species in the study area depends on species specific orientation, navigation, and bio-ecological characteristics. Additionally, factors such as the airport's natural and geographical conditions, the availability and quality of food resources, the quantity and accessibility of feeding sites, and other ecological factors also influence the probability of bird strikes.

During the breeding season, a total of 25 sedentary and migratory-wintering bird species belonging to 6 orders, 16 families, and 18 genera were recorded at Heydar Aliyev International Airport. Among the species observed in the study area, *Falco tinnunculus, Columba livia, Larus ichthyaetus,* and *Larus cachinnans* present a higher probability of collision with aircraft, and such collisions tend to have greater impact and pose significant safety risks. In contrast, species such as *Sturnus vulgaris, Galerida cristata,* and *Melanocorypha calandra* have a similarly high probability of collision, but the resulting impact and danger are comparatively lower when involving single individuals. However, when these species are encountered in flocks, the force and risk of collision significantly increase. Species such as *Apus apus, Apus melba, Delichon urbicum,* and *Hirundo rustica* are commonly observed in the airport area during the breeding season and, while the likelihood of bird strikes involving them is high, the potential impact and danger of such collisions are relatively low. Although species like *Plegadis falcinellus, Athene noctua, Pastor roseus, Corvus cornix,* and *Circus aeruginosus* have a lower probability of colliding with aircraft, any such collisions are likely to result in significant force and danger.

Species such as *Passer domesticus, Turdus merula, Motacilla alba,* and *Merops persicus* show a low probability of bird strikes; the impact of collisions involving individual birds is minimal, but the force and risk increase when collisions involve flocks.

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