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Ranking birdstrike risk: A case study at Huanghua International Airport, Changsha, China

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ABSTRACT

Bird-aircraft collisions (birdstrikes) pose a major threat to aviation safety worldwide. The bird distribution at the airfield of Huanghua International Airport in Changsha, Hunan Province, China, was investigated between December of 2006 and December of 2008, to study birdstrike avoidance and aviation safety. A total of 60 bird species was found and their risks were assessed by a birdstrike ranking assessment system. The highest-risk species were Barn swallow (*Hirundo rustica*), Red-rumped swallow (*H. daurica*), Grey-headed lapwing (*Vanellus cinereus*), Pintail snipe (*Gallinago stenura*), Oriental skylark (*Alauda gulgula*), Little egret (*Egretta garzetta*), and Eurasian woodcock (*Scolopax rusticola*), whereas the lowest-risk species were Black-capped kingfisher (*Halcyon pileata*) and White-throated kingfisher (*H. smyrnensis*). Through a hierarchical cluster analysis, all species were classified as four groups: (1) the extremely high-risk group with a risk level between 84% and 100%, which includes bird species ranked from the 1st to the 16th, and is the priori group in birdstrike prevention; (2) the high-risk group with a risk level between 71% and 81%, which includes bird species ranked from the 17th to the 28th, and is the sub-prior group in birdstrikes; (3) the sub-high-risk group with a risk level between 60% and 69%, which includes bird species ranked from the 29th to the 43rd, and is the concern group in birdstrike prevention; (4) the low-risk group with a risk level between 60% and 69%, which includes bird species ranked from the 44th to the 60th, and is the negligible group in birdstrike prevention. Finally, the first 16 bird species with high-risk values, which are the main focus of birdstrike prevention, were categorized as six prevention groups by a hierarchical cluster analysis. Therefore, this study provides targeted implementations for birdstrike prevention at Huanghua International Airport, Changsha.

1. Introduction

Accidents in which birds collide with aircrafts are called "birdstrike" [1]. As a natural disaster, bird strike is always a threat to aviation. A serious case can lead to serious problems such as plane crashes and human death. The dangers encourage more awareness for birdstrike prevention [2–5]. Military and civilian airports around the world have taken various measures to reduce these accidents [6–9]. Early birdstrike prevention, which had a high cost and low effectiveness because it injured too many birds that were not necessarily harmful, involved killing birds as a prevention method. In actuality, different birds have different levels of threat [10], so the effective approach to prevention is to survey birds' conditions and rank their risks [11–13].

In the beginning, airport staff was inclined to use the number of birds striking aircrafts to rank the risk [14]. Dolbeer et al. ranked 21 species groups for relative hazard to aircraft based on the percentage of strikes causing damage, major damage, an effect-on-flight, and mean body mass. They found that the relative hazard score was strongly related ($p < 0.01$) to mean body mass for the 21 species groups [15]. Carter and Rescue proposed a formula in which 10 primary risk factors was presented to determine the relative threat posed by individual species or groups of similar species [16]. Zakrajsek and Bissonette applied Dolbeer's idea to establish a birdstrike index assessment model, which was used to assess the birdstrike risk to military aircraft [17]. Shaw and McKee found the index of birdstrike risk in airports by taking into consideration the bird population density, the number of birdstrikes per 10,000 flights, and the number of planes with different cargo at nine airports in Eastern Australia [18].

In China, research in the field of aviation ornithology has been growing since the 1990s, and has been paying most attention to birds' conditions and birdstrike prevention measures [19–21]. However, there is less research on birdstrike assessment. Li, through analyzing the birdstrike risk factors including the birds' comparative importance value, distribution coefficient, density,

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and probability of interactive encounter, and adding to the behaviors of birds in airport clearance zone, identified the bird species that have the potential to threaten flight security in Baita Airport, Hohhot, China [22]. The study was unable to show the risk value of birdstrike. Wang, who chose four main risk factors (density, body length, meeting frequency and average height), identified a simple and useful method to evaluate the risk of birds based on useful mathematic methods [23].

Because of its special geographical environment and the steadily increasing amount of flights, birdstrikes take place often at Huanghua International Airport, Changsha. To understand birds' community ecological characteristics, we made a systematic analysis on birds' community diversity in the airport's clearance zone from March, 2005, to August, 2006. (The area is based on the center of airport as a dot with a radius of 8 km.) Between December of 2006 and December of 2008, we investigated and monitored birds' conditions in flight zone of Huanghua International Airport, Changsha (within the airport's boundary). By establishing a birdstrike risk assessment system, we determined a birdstrike risk value for every bird and the prior group. This process aimed to promote the validity of the prevention.

2. Study sites

The study area was the flight zone of Huanghua International Airport, Changsha, at 113°13′13″E, 28°11′28″N and altitude of 60 m. The area includes the airstrip (3200 m × 45 m), taxiway, parking apron, meadow, and buildings such as passenger terminals and the control tower. The total area of Huanghua International Airport, Changsha is 330 hm^2 and it has a middle subtropical humid monsoon climate, with a mean annual temperature of 17.6 °C and average annual rainfall of 1389.8 mm. The vegetation is a wild native herb community, including Rhizome imperatae (*Imperata koenigii*), Cogon grass (*I. cylindrical*), and Annual fleabane (*Erigeron annuus*). Other areas have clusters of Poisonous eightangle (*Miscanthus sinensis*), accompanied by varieties of weeds. The boundary is surrounded by scattered woods, a residential area, farmland, and ponds [24].

3. Materials and methods

3.1. Survey methods

Using a sample method, four quadrants with a total area of 194 hm^2 along the patrol road, from the boundary to the runway, were settled, including A (3400 m × 200 m), B (1200 m × 200 m), C (800 m × 400 m) and D (1400 m × 500 m) (Fig. 1). From December, 2006, to December, 2008, we chose three days that had the best weather with high visibility to gather information. These three days were chosen from the first, second, and last ten days of each month. By means of walking or cycling, the four quadrants were surveyed repeatedly by a group of two people from 7:00 a.m. to 9:00 a.m., 11:30 a.m. to 12:30 p.m., and 5:00 p.m. to 7:00 p.m. The surveyors observed and recorded bird species, songs, activities, and habitats. They observed the process of birdstrike prevention by using binoculars (10 × 25 Swarovski Habicht), a 60× monocular (Swarovski ATS80HD), an infrared ambulator (Swarovski), a GPS hand-held locator (Garmin Vista), a professional digital camera (Canon 20D 8-million pixel) and telephoto lens (100–400 mm), a high-definition digital camcorder (Sony HVR-A1C) and a mini digital voice recorder (Olympus). For lack of night observation devices, we used nets to hunt birds at night.

3.2. Data statistics and risk factors assessment

To objectively reflect the level of threat of each bird to aircrafts, the selection of birdstrike risk factors should be as comprehensive as possible. Consulting the 10 birdstrike risk factors posed by Carter and Rescue and in consideration of the conditions in Huanghua International Airport, Changsha, 11 factors were determined [16]. According to the survey results for bird conditions and effect analysis of birdstrike prevention in the flight area, these 11 factors were marked by decimal scores. The higher the score, the greater the risk. We also used 10, 5, and 1 to notate the difference between three levels (Table 1). The seven factors that were recorded during observation were encounter frequency (average individuals per day in one year), population size (individual numbers in each cluster), the main activity position (location in the flight zone), activity period, flight height, travel frequency (activity status), and avoidance ability. The factors were then scored according mean value or average level, and body weight according to mean body weight by measuring birds and consulting the book, *A Handbook of the Birds of China* [25,26]. Scoring for the following three factors requires a long-term observational record: residence time (months staying in this area), annual capture number (aggregate number of birds hunted by net each year), and control difficulty (effect of anti-bird measures within a week).

The assessment model for birdstrike risk level is as follows: $RE = (R/R_{max}) \times 100\%$. Therein, RE stands for the relative birdstrike risk percentage for each bird; R stands for the birdstrike risk value for each bird, $R = \log X$, and X stands for the product of the score of birdstrike factors; R_{max} stands for the maximum birdstrike value at risk. According to the birdstrike risk value and relative birdstrike

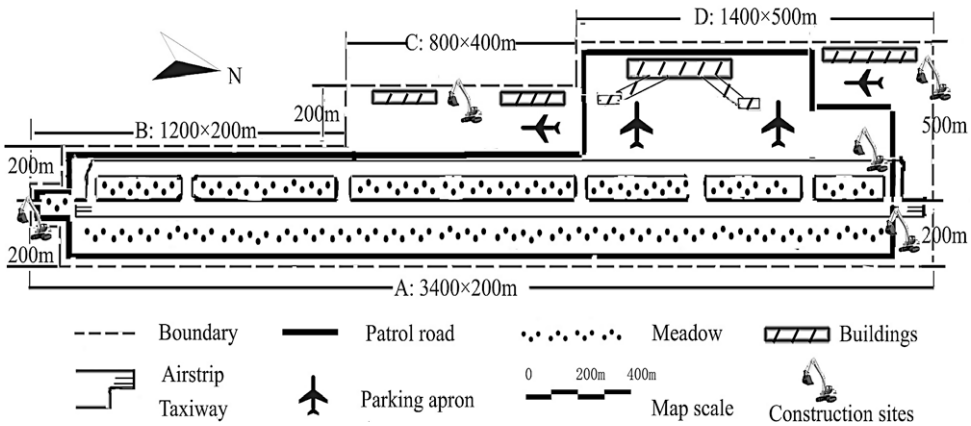

Fig. 1. Quadrant settings at the airfield of Huanghua International Airport, Changsha.