Predicting Wildlife Strike Patterns for Urban Air Mobility

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Introduction

A primary way of understanding the significance of wildlife strikes is through data collection and analyses. Previous studies have found similarities between urban air mobility (UAM) and helicopter operations in an urban environment. For example, UAM vehicles will generally operate at lower altitudes and airspeed above congested airspace than traditional air travel. Almost 95% of the wildlife strikes to aircraft occur at or below 3,500 feet above ground level. Thus, wildlife strikes are expected to pose a significant threat to UAM. UAM has yet to be fully implemented, so there is a need to develop empirical knowledge based on the scientific analyses of wildlife strike data to inform the safety management of UAM. The purpose of this ongoing study is twofold: to identify wildlife-strike to helicopters trends; and to identify the potential predictors of damaging wildlife strikes to helicopters.

Hypothesis

Null Hypothesis (H0): There is no significant relationship between the 6 independent variables and the binary outcome of non-damaging and damaging strikes.

Alternative Hypothesis (H1): At least one of the 6 independent variables has a significant effect on the binary outcome of non-damaging and damaging strikes.

Figure 1. Wildlife Poses a Threat to Aviation Operations

Methodology

Wildlife-strike data from 2013 to 2022 was retrieved from the Federal Aviation Administration (2023) Wildlife Strike Database. Six independent variables were analyzed from the data: time of day, height, phase of flight, size of animal, airspeed, and sky condition. Each variable was categorically organized depending on the values it represents. Number of damaging and non-damaging strikes was analyzed for each variable. The time of day was divided into dawn, day dusk, night. Height was divided into 500 feet (ft) intervals starting from 0 ft to 4000ft. Phase of the flight was divided into the approach, arrival, climb, departure, descent, en-route, landing roll, local, parked, take-off run, and taxi. The size of the bird was divided into large, medium, and small. Airspeed was labeled into 50 knots (kts) intervals starting from 0 kts. Sky conditions were divided into no cloud, overcast, and some cloud. SPSS was used for this project. First, descriptive data was used to analyze the overall trend of strikes to helicopters. Initially, binary logistic regression was used to predict binary outcome of non-damaging and damaging strikes.

Results

The Omnibus Tests of Model Coefficients was significant with $p < 0.001$ and $\chi 2 = 285.322$, meaning further evaluation of model was needed. To test the fit of data, two tests were performed - Cox & Snell $r^2 = 0.157$, while Nagelkerke $r^2 = 0.268$. Both tests should be more than 0.2 for model to be perfect. However, if one is larger and the other is smaller, + model is considered to be acceptable. Lastly, Hosmer & Lemeshow test indicated $p = 0.627$. This means that data fits the prediction model (closer to 1, means stronger fit).

Variables in Equation

Predictor	Predictor Level	Significance Value (*p*)
Time of Day	Dawn	0.029
Phase of Flight	Climb	0.036
Speed	51-100kts	0.037
Bird Size	Small	< 0.001
Bird Size	Medium	0.009
Bird Size	Large	< 0.001

Total number of cases (strikes) analyzed was 1676. 267 of those were strikes with indicated damage. Damaging strikes per each independent variable: time of day (dawn) – 1 case, phase of flight (climb) – 11 cases, speed group between 51 to 100kts – 72 cases, small bird size – 57 cases, medium bird size – 74 cases, and large bird size – 52 cases. Model prediction accuracy – 84.7%.

Discussion and Conclusion

The null hypothesis of the binary logistic regression was rejected. The key predictors for damaging strikes are time of day (dawn), phase of flight (climb), speed range of 51 to 100 knots. Furthermore, majority of damaging strikes (27.7%) were caused by medium sized birds, which aligns with the FAA (2023) report indicating that most damaging strikes were caused by medium-sized waterfowl like geese and ducks. Helicopters and UAM will share similar flight profiles, including cruising speeds of 55-120 knots. This may be of concern because 27% of damaging strikes occur within the 51-100 knot range. Additionally, migration and nesting areas must be considered when establishing vertiports and planning routes to mitigate the risks based on key predictors. It is crucial for the aviation industry to utilize wildlife-strike data and continue further research to enhance hazard management programs, improve pilot awareness, and refine strategies for mitigating wildlife strike risks for both helicopters and UAM.

Figure 2. Medical helicopter crash killed 3 due to impact by geese in Oklahoma

Limitations

The main limitation of this research was that it relied solely on the Wildlife Strike Database, a voluntary reporting system that may include subjective data. Additionally, a significant number of missing cases prevented the inclusion of a larger sample size.

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