Quantification of avian hazards to military aircraft

Morgan B. Pfeiffer, Bradley F. Blackwell, Travis L. DeVault
The issue: bird strikes with military aircraft

- Human safety
- Annual costs $35 million for United States Air Force (USAF)\(^1\)
- Not as well studied

\(^1\) (Zakrajsek and Bissonette 2005)
Why expect different patterns than civil aviation?

- Variety of airframes (cargo, fighters, etc.)
- Long flight durations at low altitudes (Dolbeer et al. 2006)
- Greater speeds
Prioritize avian management for military airfields

- Over 700 wildlife species struck by military aircraft
- Focus time and resources on a subset of these species

Original Article

Estimating Interspecific Economic Risk of Bird Strikes With Aircraft

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Zakrajsek and Bissonette 2005

Hazard Index

\[
HI_S = (C_S \times W_C) + (B_S \times W_B) + (A_S \times W_A),
\]

Weights were constant regardless of species and based on a monetary index

Which species cause the most damage?
Relative Hazard Scores (RHS)

- Which species are the most hazardous if struck?
Hypotheses

- Airframe and avian body mass would influence RHS (DeVault et al. 2011)

- Region (Pfeiffer et al. 2018)

- Reporting military branch
  - Mandatory reporting USAF > 20 years
  - Mandatory reporting United States Navy (USN) since 2017
Data Filtering

- ONLY avian species (groups) struck > 20 times in the US
- Not filtered based on altitude, airframes grouped

<table>
<thead>
<tr>
<th>Damage Class</th>
<th>Associated monetary Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>&gt; $2,000,000</td>
</tr>
<tr>
<td>B</td>
<td>$500,000 – $2,000,000</td>
</tr>
<tr>
<td>C</td>
<td>$50,000 – $500,000</td>
</tr>
<tr>
<td>D</td>
<td>$20,000 – $50,000</td>
</tr>
<tr>
<td>E</td>
<td>&lt; $50,000</td>
</tr>
<tr>
<td>H (damaging)</td>
<td>&gt; $55</td>
</tr>
<tr>
<td>H (non-damaging)</td>
<td>≤ $55</td>
</tr>
</tbody>
</table>

Minor Damage

Substantial Damage
- 1,237 strikes
  - 15 strikes with substantial damage
  - 90 with minor damage
  - 1,147 no damage

<table>
<thead>
<tr>
<th>Species</th>
<th>% damage</th>
<th>Damage rank</th>
<th>% sub. damage</th>
<th>Sub. damage rank</th>
<th>Sum of ranks</th>
<th>Sum of %</th>
<th>RHS</th>
<th>Composite rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>American Kestrel</td>
<td>7%</td>
<td>68</td>
<td>1%</td>
<td>51</td>
<td>119</td>
<td>8%</td>
<td>7</td>
<td>58</td>
</tr>
</tbody>
</table>

Max is 116% (Snow goose)

Out of 108 species (groups)

\[
\frac{8}{116} = 6.89
\]
- Compare RHS among military and civil airframes
- Examine the relationship between body mass and RHS
- Use AIC model ranking to determine the best combination of predictors
Results

- % of strikes removed because species was unknown
  - USN – 62% removed
  - USAF – 20% removed

- Final number of strikes used
  - USN – 4,136 (11%)
  - USAF – 34,990 (89%)

<table>
<thead>
<tr>
<th>Damage Class</th>
<th>Number of Strikes</th>
</tr>
</thead>
<tbody>
<tr>
<td>A/B/C (substantial)</td>
<td>1,001</td>
</tr>
<tr>
<td>D/E/H (minor damage)</td>
<td>3,239</td>
</tr>
<tr>
<td>Species</td>
<td>% with damage</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>---------------</td>
</tr>
<tr>
<td>Snow goose</td>
<td>74</td>
</tr>
<tr>
<td>Common loon</td>
<td>70</td>
</tr>
<tr>
<td>Black vulture</td>
<td>58</td>
</tr>
<tr>
<td>Canada goose</td>
<td>56</td>
</tr>
<tr>
<td>Turkey vulture</td>
<td>48</td>
</tr>
<tr>
<td>Northern pintail</td>
<td>44</td>
</tr>
<tr>
<td>Mallard</td>
<td>45</td>
</tr>
<tr>
<td>Swainson’s hawk</td>
<td>41</td>
</tr>
<tr>
<td>Double-crested cormorant</td>
<td>44</td>
</tr>
<tr>
<td>Herring gull</td>
<td>32</td>
</tr>
<tr>
<td>Red-tailed hawk</td>
<td>37</td>
</tr>
</tbody>
</table>
Results

- Binary logistic regression for damage or not and substantial damage or not

  - Best models included:
    - Flyway
    - Airframe
    - Body mass
    - Military branch
    - Airframe × body mass

  - Airframe, body mass, and Airframe × body mass significant
Results

- Migration flyway significant for probability of substantial damage (Pacific)

- Military branch significant for probability of substantial damage (USAF)
Discussion

- First RHS for military aviation calculated
- Need to incorporate frequency data
- Need monetary independent data to evaluate
Discussion

- Airframe and avian body mass influenced RHS
- Region was significant at predicting substantial damage
- Reporting military branch was significant at predicting substantial damage
Conclusion

- Military avian RHS were different than civil
- RHS differed per airframe and with avian body mass
- RHS prioritize wildlife management absent a risk estimate
- Only as accurate as the data provided
Acknowledgments

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- Office support: Betsy Poggiali
Questions?

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