# Know Thy Enemy: Using Drones to Evaluate Composition and Size of Blackbird Flocks Foraging in Commercial Sunflower


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## Background

- Blackbirds cause damage estimates of US$3.5 million annually to oilseed sunflower in the Prairie Pothole Region of North Dakota [1].
- Drones provide a dynamic threat to pests [2], hold the potential to provide long-term protection, and can be used to minimize blackbird damage in sunflower [3,4,5].
- The composition (i.e., species, sex, and age) of blackbird flocks is subject to change throughout the damage season as the transition from breeding to molt and migration is variable for subsets of the population.
- Few studies have used automated detection and counting of wildlife in complex and varied environments [6,7,8,9], and we are not aware of any AI to count or identify blackbirds foraging in commercial sunflower.

## Objectives

We used high-quality drone imagery to address 3 objectives (Fig. 1,2):

1) Compare an automated count (i.e., ImageJ) to biologist counts.
2) Apply a machine learning approach to detect and count blackbirds.
3) Manually count and classify blackbirds by species, age, and sex to understand seasonal phenology.

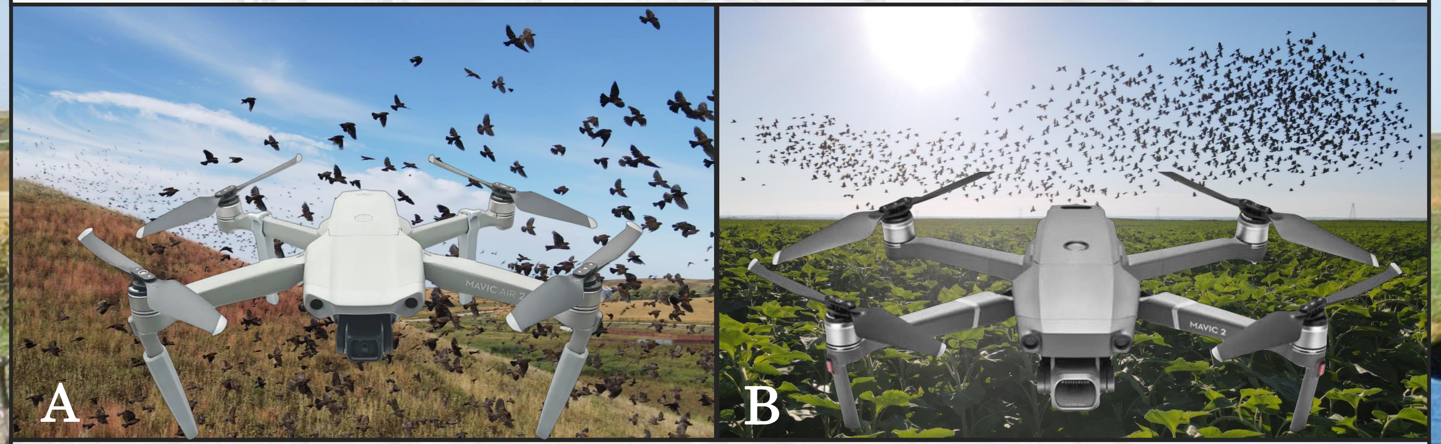


*Figure 1: We operated two drones: A) the DJI Mavic Air 2 (DJI, Shenzhen, China) and B) the DJI Mavic 2 Pro (DJI, Shenzhen, China) flown simultaneously by two pilots, in a highly coordinated manner to capture RGB imagery for evaluating flock composition and size.*

## Methods

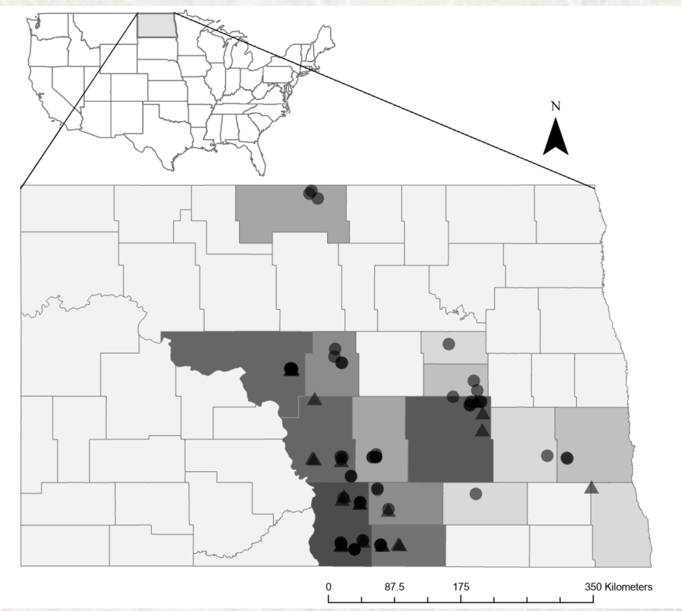

*Figure. 2: We conducted drone flights in commercial sunflower and adjacent cattail marshes in North Dakota, to obtain imagery for flock size and composition analyses of mixed-species blackbird (Icteridae) flocks from September to October 2021–2022.*

### Automated v. Biologist Counts

- We used photos with a high contrast between birds and background (e.g., sky) for automated detection and counting in ImageJ.
- We gathered biologist estimations using Google forms.
- We evaluated the role of flock size, experience and photo order on the difference (%) between methods using LMM (Fig. 3).

### Development of an A.I. Model

- We trained a faster-RCNN algorithm to detect and count blackbirds in images taken from 01 Sept. to 30 Oct. 2021–2022.
- We used 'LabelImg', an open-access image annotation tool, to manually label individual birds with bounding boxes in 54 video frames.
- We evaluated the performance of the testing data set by calculating accuracy, precision, and recall to detect a blackbird.

### Manual Flock Composition Determination

- We manually classified birds by species, including red-winged blackbirds, yellow-headed blackbirds, and common grackles and further classified red-winged blackbirds by sex and age (Fig. 4).
- We used qualitative measures to evaluate changes in flock composition on a state-wide scale over the damage season (Fig. 5).

## Results

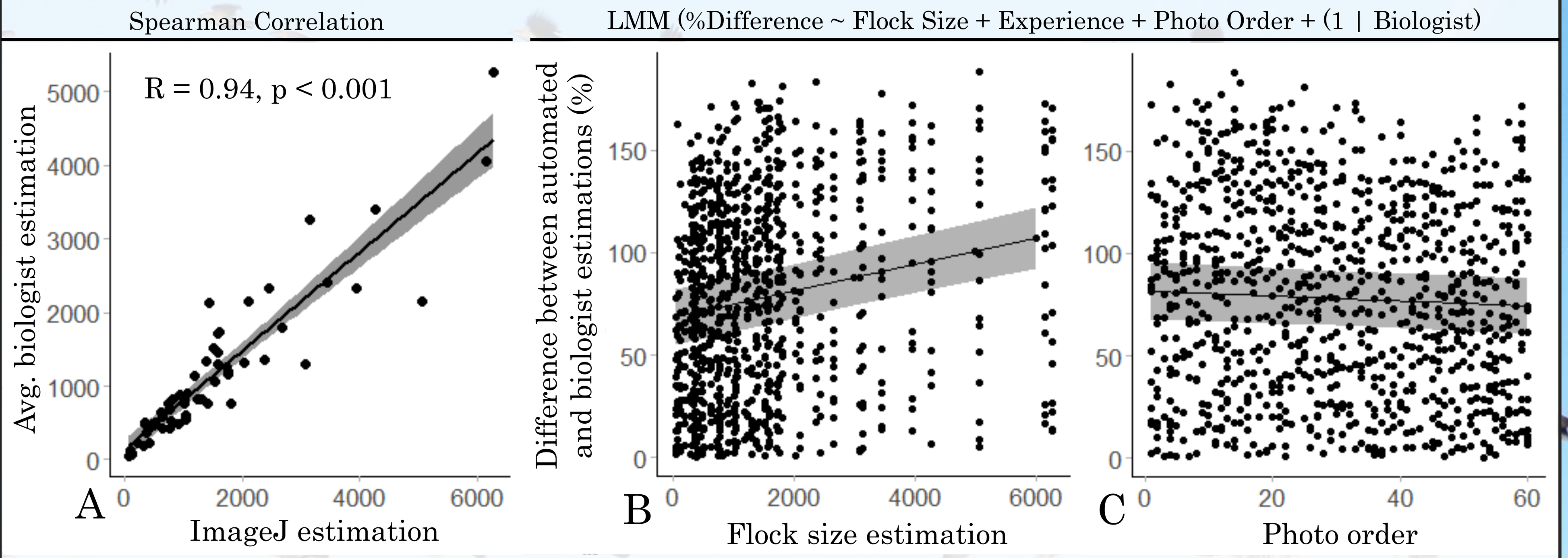


*Figure 3: A) The correlation between automated and biologist flock size estimations and the percent difference between automated and biologist counts as a function of B) flock size and C) photo order. The estimates of flock size were obtained from drone imagery collected from 31 Aug. to 26 Oct. 2021–2022 in sunflower (Helianthus annuus) fields being actively damaged by mixed-species blackbird flocks in North Dakota, USA. The grey shaded area indicates a 95% confidence interval.*

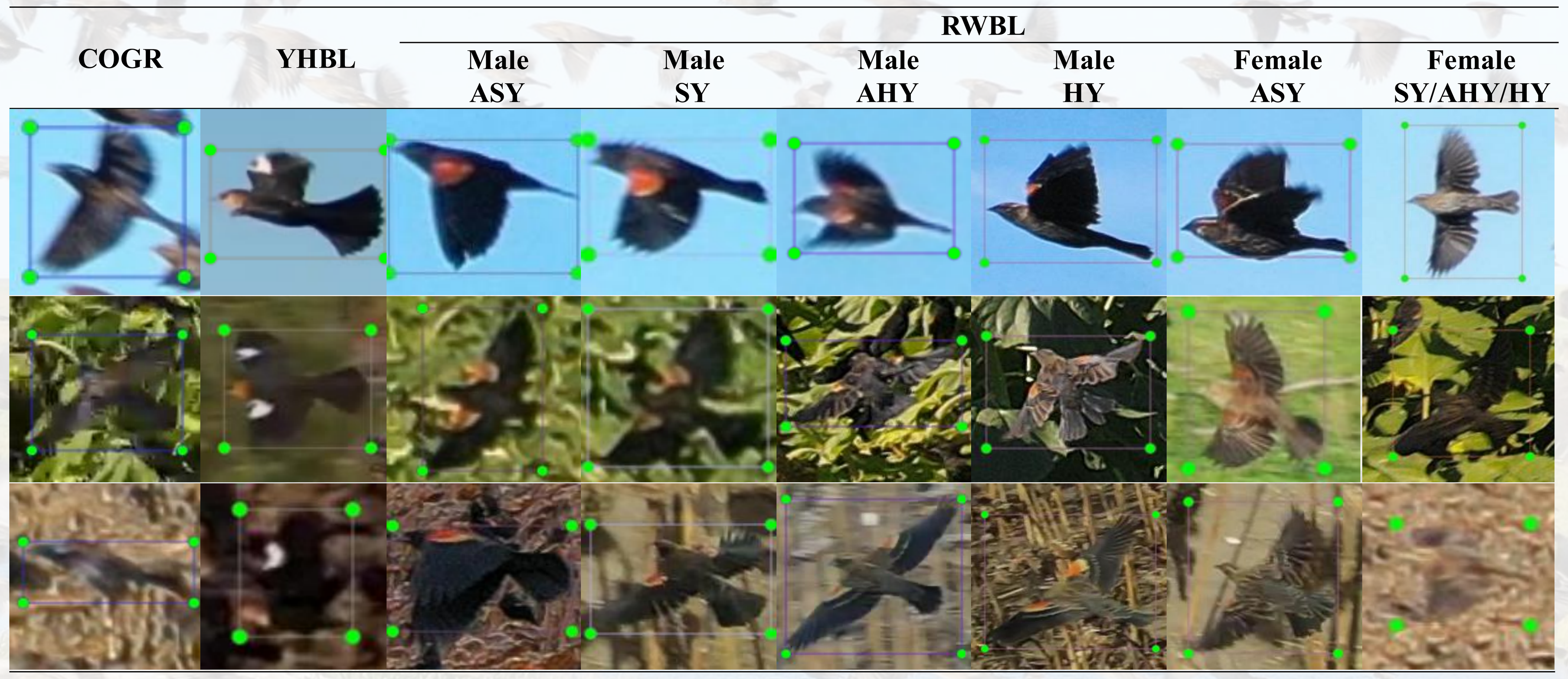


*Figure 4: Classified birds, including common grackles (COGR), yellow-headed blackbirds (YHBL), and red-winged blackbirds (RWBL) on the most common backgrounds (i.e., sky, green vegetation, and brown vegetation). RWBL photos include after second year (ASY) male, second year (SY) male, after hatch year (AHY) male, hatch year (HY) male, ASY female, and SY/AHY/HY female. Examples sourced from video frames and photos taken during drone flights in and around sunflower (Helianthus annuus) fields being damaged by mixed-species blackbird flocks in North Dakota, USA from Sept. to Oct. 2021 and 2022.*

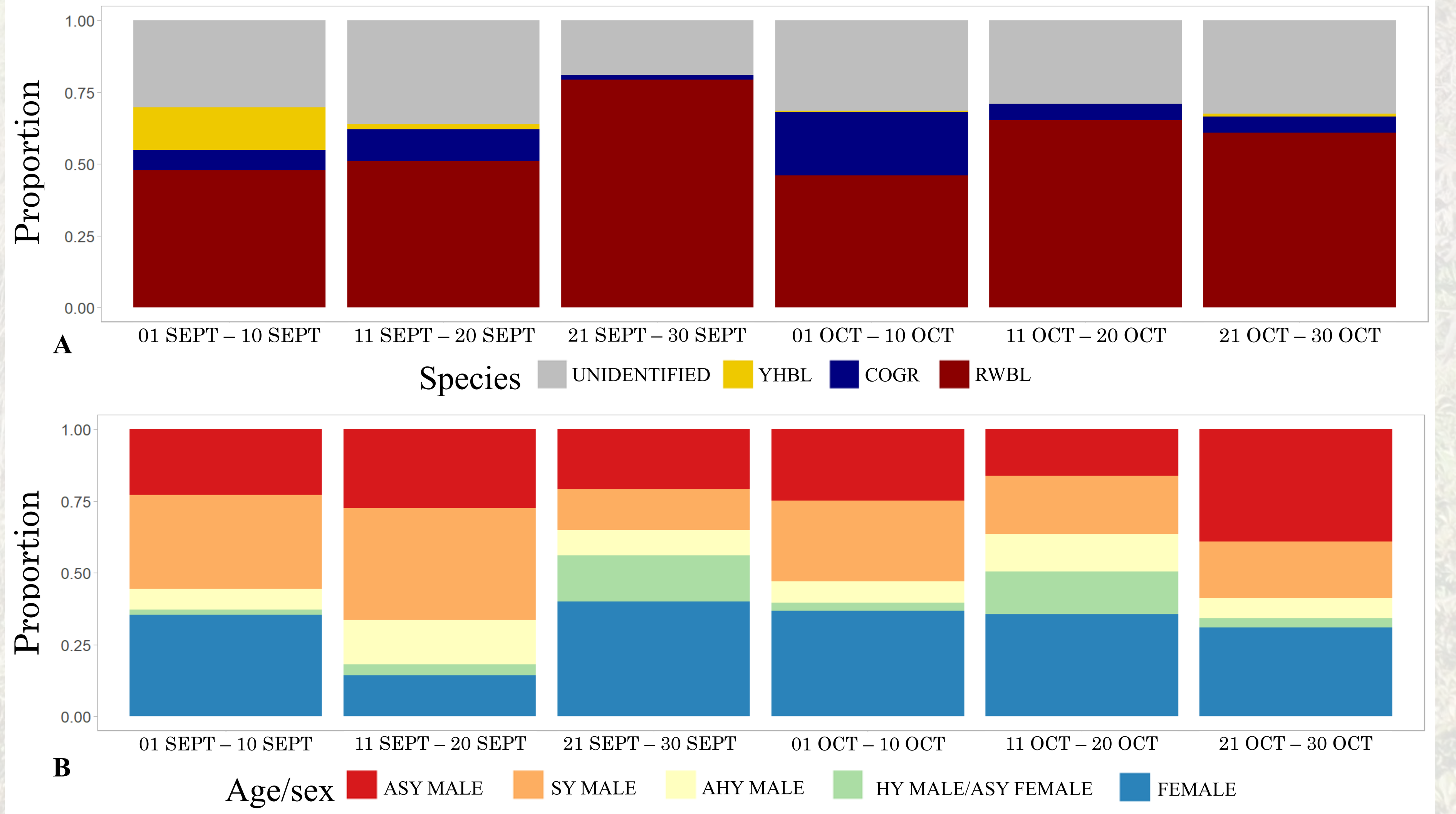


*Figure 5: A) Proportion of red-winged blackbirds (RWBL), yellow-headed blackbirds (YHBL), and common grackles (COGR) and B) proportion of each sex and age class of RWBL found flocking in and around sunflower (Helianthus annuus) fields in North Dakota, USA over a 60-day period (01 Sept. to 30 Oct.) in 2021 and 2022. Percentages were calculated by averaging the classification counts in 3 video frames taken per drone flight divided by the total birds detected in the frame. Each 10-day interval summarizes 3 separate trials (3 video frames per trial). Observers manually classified individual birds into categories using an open-source image annotation tool, 'LabelImg' (Tzutalin; v1.8.1).*

## Summary

### Automated v. Biologist Counts

- Automated counts ranged from 57-6,272 birds (1,489 ± 40), while biologist counts ranged from 25-50,000 birds (1,138 ± 66).
- When counting birds, automated counts should be considered when a standardized method is required.
- Drone FOV limits a pilot's ability to capture the entire flock in a single frame, thus field estimates by biologists are still necessary.

### Development of an A.I. Model

- The accuracy of the faster-RCNN algorithm was 25.4%, precision was 86.3% and recall was 26.4%.
- Quality and quantity of drone imagery is important in developing automated count and classification methods, and limitations exist when backgrounds are highly complex and variable.

### Manual Flock Composition Determination

- This study provided a foundational understanding of the species present during the sunflower damage season.
- Our findings align with the early molt of the YHBL, and the later molt of the COGR and RWBL, however no trends were found to suggest early departure of female and young male RWBL.

## Future Directions & Recommendations

This research has taken important steps in identifying limitations and determining feasibility of developing an AI detection model. Future steps to improve detection and classification performance include:

- Developing models specific to subject color or background color.
- Increasing shutter speed, reducing drone speed, or using multiple drones in coordination to reduce subject blurriness.
- Substitute video footage for still imagery.

Our findings on flock composition may further inform hazing optimization, given the dominant species, age, or sex could be used as an additionally explanatory variable to determine if subsets of the blackbird population respond differently to tools or methods.

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