EEB313 Mid-project Update
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Hypotheses

1. The intensity of artificial light at night affects the frequency of bird-building collisions among passerine birds during nocturnal migration.
2. The frequency of bird-building collisions varies among species.
3. The frequency of bird-building collisions varies seasonally.

Predictions

1. The frequency of bird-building collisions increases with the intensity of artificial light. *(Samina)*
2.
   a. The frequency of bird-building collisions increases in species with greater maneuverability. *(Yunhua)*
   b. The frequency of bird-building collisions is lower in omnivory species. *(Leslie)*
3. The frequency of bird-building collisions is higher in autumn than in spring. *(Chunnan)*

Author contributions

Each of us was responsible for the rationale, data manipulation and analysis for one prediction as indicated above.

Rationales for predictions

For prediction 1

Attraction to lighted buildings at night presents a danger to migrating bird populations, particularly in dense urban areas (Winger et al. 2019), so we predict that bird-building collisions will *increase* with the intensity of artificial light.

Why we changed our prediction

To add directionality to our predictions, we replaced the original predictions that the frequency of bird-building collision varies among species and species with particular characteristics with the new predictions indicating the particular trait (prediction 2a & 2b).

For prediction 2a

Fernández et al. 2018 shows species with lower wing loading (a measurement related to body mass and wing area) indicate greater maneuverability, and had a higher frequency of collisions with aircraft. The model containing wing loading had the best fit to account for the variance in bird collisions across species, suggesting that birds with lower wing loading get struck at a higher rate at airports. Therefore we predict greater maneuverability is also associated with higher bird-building collision frequency.

For prediction 2b

For prediction 2b, Wittig et al. found that omnivorous bird species have significantly lower bird-building collision frequency compared to non-omnivorous bird species, so we are going to test this argument with our data.

For prediction 3

Previous studies have examined the relationship between various weather conditions during spring and autumn migration seasons respectively and bird-building collision incidents. It is found that collision rates are notably sensitive to specific weather conditions. Research indicates that bird-building collisions are primarily influenced by higher temperatures, south wind directions, and precipitation during the spring season, while days with colder temperatures, north wind directions, increased visibility, and atmospheric pressure contribute to *higher collision incidents in autumn* (Scott et al. 2023). The study focuses on non-nocturnal flight birds and restricted recordings of weather conditions and collision incidents within dawn time. Nevertheless, they offer valuable insights into the potential impact of varying weather conditions between spring and autumn, which may contribute to different collision patterns during different migration seasons.

<u>Description of data</u>

Bird-building collisions were monitored in Chicago, Illinois and Cleveland, Ohio, USA. Chicago bird-building collision data for 1978 to 2016 was collected by Winger and colleagues. Collisions were counted daily at two sites during migration periods in autumn and spring. Cleveland bird-building collision data for autumn 2017 to spring 2018 was provided by a local volunteer organization, but we will not be using this data because there are no measurements of light intensity associated with it and the method of data collection is not specified.

The dataset comprises three distinct data frames: Chicago_collision_data, Cleveland_collision_data, and light_levels_Dryad. We will use the columns 'Genus', 'species' and 'date' from Chicago_collision_data. We will also use the columns 'light_score' and ‘date’ from light_levels_Dryad, which quantifies the light intensity by date at one of the Chicago sites.

Our data manipulation and analyses will differ slightly for each prediction, so we have discussed them one prediction at a time in the next section.

<u>Data manipulation and analysis</u>

For prediction 1

For this part of the project we are using both the 'Chicago_collision_data' and 'Light_levels_dryad' data sets. Bird collisions are not observed on all days when light intensity is quantified, so we are creating a new data frame which pairs bird collisions with dates and their respective levels of artificial light. This also involves converting observations of bird-building collisions in Chicago_collision_data (each row = an observation of a bird-building collision) to count data (frequency). There are several collisions (rows) for a given date, and we want to know how the total number of collisions varies by date (because each date is associated with a given light level).

We can then visualize the data on a histogram with level of artificial light on the x-axis and frequency of bird-building collisions on the y-axis. For our analysis, we will use a linear mixed model to regress light level onto bird-building collisions to determine if artificial light is a statistically significant predictor of bird-building collision. Date will be considered a random effect, since collisions are not independent and may vary from day to day (e.g. because of a large bird group flying past, or due to particular conditions on that day). We will examine residual plots to assess normality and homogeneity of variance.

For prediction 2a

In the data preparation phase, the task involves extracting species names from the given dataset, followed by the collection of average body mass and wingspan data for each species from the Avibase world bird database. Subsequently, wind load is calculated for each species body mass divided by wingspan. The prepared datasets are then meticulously cleaned to rectify any missing or incorrect values. Finally, the bird collision dataset is merged with the wind load dataset, using species names as the key.

During exploratory data analysis (EDA), the focus is on visualizing the distribution of bird collisions across different species via histograms, with an arrangement based on wind load. This visualization aids in the identification of any discernible patterns or correlations between the incidents of bird collisions and their respective wind loads.

The regression analysis is to establish a model that illustrates the relationship between wind loading and the frequency of bird-building collisions. A simple linear regression is considered as the initial approach for this analysis. Hypothesis test using ANOVA to evaluate the statistical significance of the associations observed between wind loading and bird collisions. This step is critical to confirm that the patterns identified are not due to random chance but show a significant relationship.

For prediction 2b

We will first collect data on the 91 bird species' food sources (trophic niche) from the database Avibase-The World Bird Database. Then we will merge the species' food source data with the bird-building collision data. To count each species' collision frequencies, we will visualize collision frequencies across species using histogram while grouping species by their trophic niches (omnivores vs. others). By looking at the y-axis, we have the collision frequencies of two groups of birds, which we will use t-test to determine whether their means differ significantly. To check assumptions of t-test, we will plot histograms for normal distribution of the data, and we will calculate and compare their variances for homogeneity of variances.

For prediction 3

Only the 'Chicago_collision_data' is used. To organize the data frame, we will first create a new column: spring migration contains data gathered during April and May per day by adding all the incidents among species and new column: autumn migration contains data gathered during September and October per day by adding all the incidents among species. Then we will create two new columns for the seasonal counts by adding all the daily counts together for each migration season over the total span of 38 years. To verify our prediction, we will examine the distribution of data to determine the type of t-test we are going to use. Then we will compare the means (t-test) or distributions (Mann-Whitney U Test) of the two sets of data.

References

Original publication of the data we will be working with

Winger BM, Weeks BC, Farnsworth A, Jones AW, Hennen M, Willard DE (2019) Nocturnal flight-calling behaviour predicts vulnerability to artificial light in migratory birds. Proceedings of the Royal Society B 286(1900): 20190364. https://doi.org/10.1098/rspb.2019.0364

Dryad data package

Winger BM, Weeks BC, Farnsworth A, Jones AW, Hennen M, Willard DE (2019) Data from: Nocturnal flight-calling behaviour predicts vulnerability to artificial light in migratory birds. Dryad Digital Repository. https://doi.org/10.5061/dryad.8rr0498

Other references

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Loss SR, Lao S, Eckles JW, Anderson AW, Blair RB, Turner RJ. Factors influencing bird-building collisions in the downtown area of a major North American city. PLoS One. (2019). Nov 6;14(11):e0224164. doi: 10.1371/journal.pone.0224164. PMID: 31693699; PMCID: PMC6834121.

Wittig, T. W., Cagle, N. L., Ocampo-Peñuela, N., Winton, R. S., Zambello, E., & Lichtneger, Z. (2017). Species traits and local abundance affect bird-window collision frequency. *Avian Conservation and Ecology, 12(1).* https://doi.org/10.5751/ace-01014-120117

Scott K.M., Danko A., Plant P., Dakin R. (2023). What causes bird-building collision risk? Seasonal dynamics and weather drivers. *Ecology and Evolution*, *13(4).* https://doi.org/10.1002/ece3.9974