Report 1: Monarch butterflies

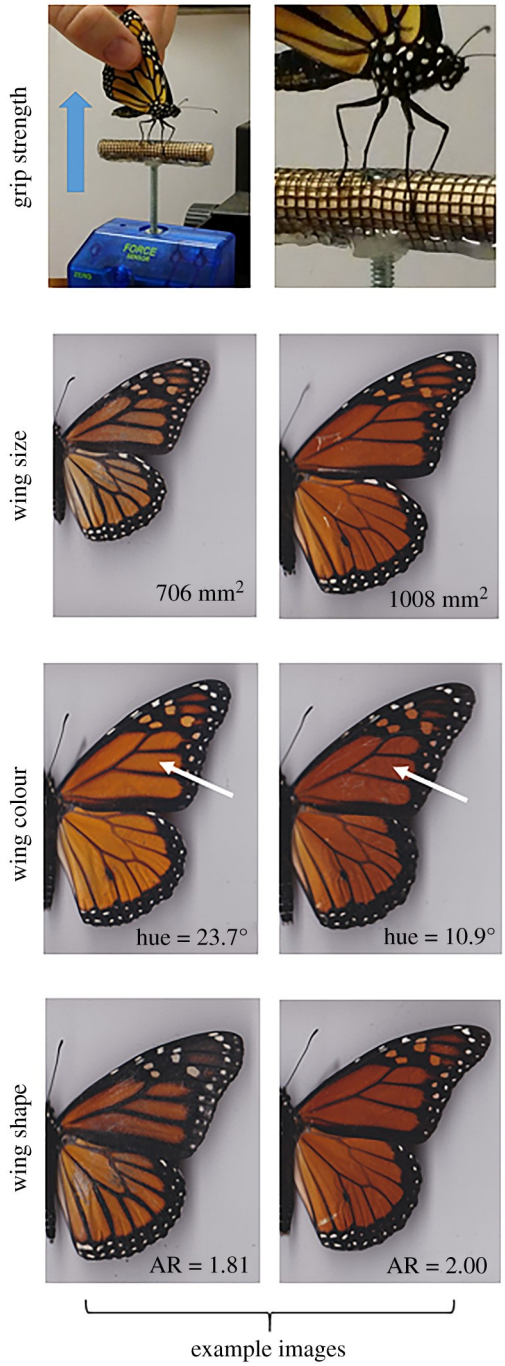
Introduction

Every year, orange and black monarch butterflies migrate from their summer breeding grounds in the US and Canada to mountain forests in central Mexico, where they hibernate for the winter. A recent study reveals a 53% decline in the population of monarch butterflies in North America from the wintering season of 2018-2019 to the wintering season in the following; this dramatic decrease is primarily attributed to habitat loss, climate change, and pesticide use[1]. For species facing substantial population declines, conservationists frequently turn to captive rearing to produce biologically indistinct individuals for eventual release into the wild. However, tagging studies have indicated that captive-reared monarchs exhibit lower migratory success than their wild counterparts. Researchers aim to compare various traits of captive-reared monarchs with those of wild monarchs to identify potential differences that may contribute to their reduced migratory success.

For this study[2], researchers raised monarchs from eggs to maturity under two different conditions. One group was raised in a warm indoor room next to a window (a "rearing room"), while the other was raised in an incubator that mimicked late summer conditions. These captive-reared butterflies were then compared to a group of wild-caught monarchs. Area, pigmentation, and aspect ratio of the monarch wings was measured by briefly chilling the monarchs (to prevent movement), placing them on their backs with their wings spread, then scanning them with a digital scanner. Grip strength was tested by measuring how many Newtons are exerted by a butterfly at the moment of release when gently tugged from a mesh covered perch. You can read more about the study following the link at the bottom of this page.

[1] WWF, 2020.

[2] Davis AK, Smith FM, Ballew AM. A poor substitute for the real thing: captive-reared monarch butterflies are weaker, paler and have less elongated wings than wild migrants. Biol Lett. 2020 Apr; 16(4):20190922. https:// doi.org/ 10.1098/ rsbl.2019.0922 . Epub 2020 Apr 8. PMID: 32264783; PMCID: PMC7211457.



The variables recorded by the researchers are as follows:

- `Monarch_Number`: An ID number assigned to each butterfly
- `Monarch_Group`: The conditions the monarch was reared under (Incubator, RearingRoom, or Wild)
- `Eclosion_Capture`: The day and month of 2019 in which the butterfly either hatched from its chrysalis or was caught in the wild
- `Sex`: Whether the monarch was male (M) or female (F)
- `MaxGrip`: The force exerted by a butterfly to remain clinging to a mesh-covered perch when gently tugged upwards until it releases the mesh, measured in Newtons
- `ForewingArea`: The area of the upper part of the left set of wings, measured in mm2 1
- `ForewingAR`: The aspect ratio, or elongation, of the left forewing, measured as length width
- `OrangeHue`: The average hue score of the central wing cell of the forewing, measured in degrees

Your task is to create a statistical report that addresses the following research question: is there a difference between the butterflies reared under each of the three conditions?

Guidelines

- Your report should feature **at least four** plots that you reference to support your conclusions
- No formal statistical methods should be included (we have not learned any yet)
- The project is intentionally open-ended. You should consider multiple different approaches for comparing the butterflies (i.e., comparing the hues, grip, areas, etc.)
- You must work with at least three other students on this report.
- Key learning objectives for this report include:
  - Developing data science skills that enable the manipulation and visualization of data in R
  - Improve your ability to convey information about data via graphics
  - Develop the ability to nicely format documents in RStudio
- Please see the rubric on the next page for grading details, and feel free to use the example report on the course website.

Report rubric

Introduction [5 pt]

- Background information is provided
- Research question is clearly articulated and motivated

Statistical procedures used [20 pt]

- Observational units, response, and explanatory variables are defined
- Data are described in detail (collection, source, etc.)
- Visualizations of the data are provided and described

Summary of statistical findings [5 pt]

- Research question is addressed, specifically referencing created visualizations

Scope of inference [10 pt]

- Findings summarized
- Scope of inference is clearly articulated

Other [10 pt]

- Formatting (.pdf, code included as appendix)
- Writing quality (no typos, etc)
- Code used to produce figures presented neatly in an appendix
- Overall impression
  - Would this report be appropriate to share with a general audience?
  - Is the document well formatted and tidy?
- See example report for expectations