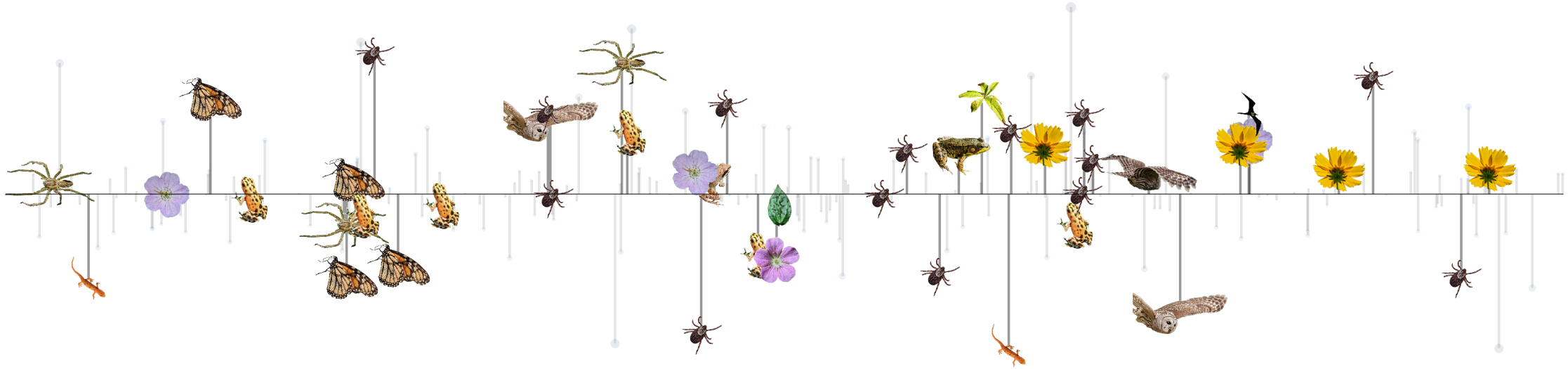
Intro to Quantitative Ecology
UMass Amherst – Michael France Nelson

Deck 12A – Interactions



Important Info Ahead!

Do not ignore

Final Projects

What are the final project expectations going to be like? Individual or group assignment? The individual final has 2 + 1 parts:

1. A complete analysis using R Markdown. You will utilize all of your R and RMarkdown skills to carry out a complete statistical analysis of a dataset.
2. A take-home question set. This will be in the form of a Moodle quiz.
3. An optional extra-credit question set: You can make 5% of course grade.
    1. Warning: these are not meant to be easy, and we can provide only minimal guidance.

The final assignments are all available now on Moodle.

Although the final assignments are individual, I encourage you to work together. Just remember that your final product must be unique, and your answers must be in your own words.

Last Class Sessions Schedule

Week 12: May 2, 4

- Tuesday: Deck 12a, b, NEON slides in-class
- Thursday: Deck 12b, NEON slides in-class

Week 13: May 9, 11

- Tuesday: Deck 12b, in-class Confidence/significance
- Thursday: Deck 13, course concepts recap, Q+A

Week 14: May 16

- Tuesday: Course concepts recap, Q+A, NEON presentations

What's Left to Turn in?

- NEON assignment
  - Revised slide (if needed)
- NEON presentations (last day of class)
- In-Class Confidence/Significance
- R Markdown 2

- Final R Guide
- Final Question set

- NOTE: We're **not** doing the Group: ANCOVA and Model Predictions assignment

Group Assignments, Attendance, and Equal Participation

- Attendance in class has been a bit… light. We are all adults, free to make our own academic decisions as appropriate to our own priorities and circumstances.
- Since we devote considerable in-class time to group assignments, I want to make sure that groups with non-attending members feel that everyone is contributing in a substantive way to the work.
- If you do not regularly attend class and/or are not part of a group for group assignments, you may make a group-of-one and complete the assignment individually. This applies to in-class assignments as well.
- Please be in touch if you have concerns about current or prior equal participation in any group assignments. I can make grade adjustments as appropriate.

Assignment Due Dates

- These are **not flexible**, except under extreme circumstances arranged **before** the due dates.
- It's important for you to be in touch ASAP if you have concerns of feel that you won't be able to meet the deadlines – if you wait until the last minute, we may not be able to help you!
- All outstanding in-class, group, and individual assignments are due by midnight on the last day of classes **(May 17th).**
- The optional extra credit question set is due by **May 25**.

Final Assignments – Due Dates

- Final question set has been released into the ether! Please take a look at it sooner rather than later, time is running short for you to ask questions in class.
- Remember to be working on your R guide.
- Reach out to Ana or I if you have any final assignment questions. Office hours and in-class are the best times for questions and demos as well because you have Ana and I as a captive audience.
- Due date for the final question set and R guide is **May 25th**. There is **no flexibility** in this date, except under extreme circumstances that have been arranged individually **before** the deadline.

Interactions and ANOVA

The Scenario: Grazing Cows

- For our example, we'll use an example of 2 breeds of cows, Holsteins and jerseys, feeding on three varieties of forage.

The predictors are:

- Grass variety: 3 levels
- Cow breed: 2 levels

The response is:

- Body mass

ANOVA Recap

Recall that Analysis of Variance ANOVA helps us understand differences in three or more groups.

- 1-Way ANOVA: Observations are grouped by a single factor: penguin species OR sex.
- 2-way ANOVA: Observations can be grouped by 2 factors: penguin species AND sex. We consider each factor separately.

Interactive ANOVA: observations are grouped by both factors **at the same time,** for example:

- Female Chinstrap penguins
- Male Adelie penguins

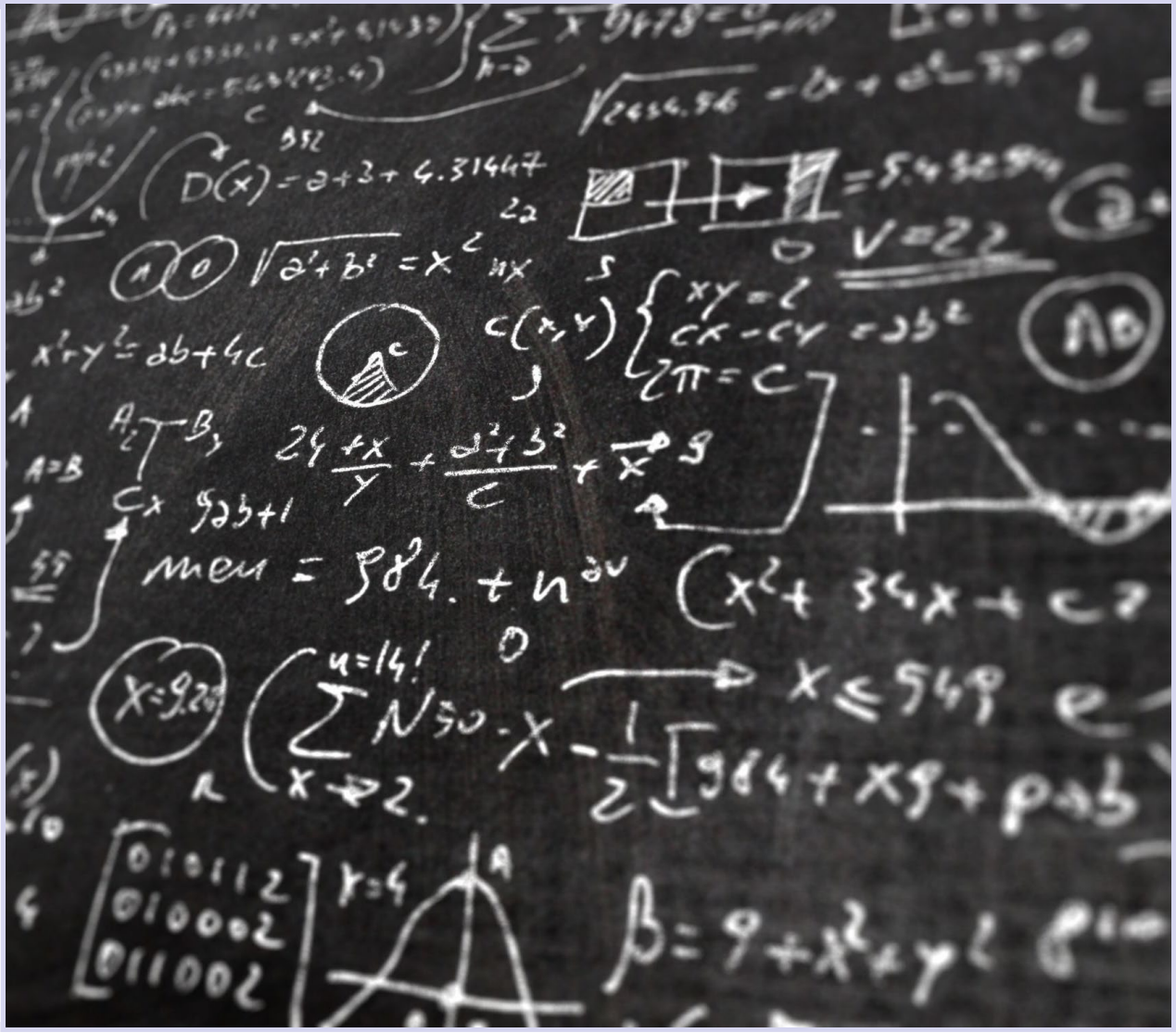
The ANOVA Null Hypothesis

ANOVA Null Hypothesis

The overall ANOVA null hypothesis is simple:

All group means are the same!

- Male and female penguins have the same body mass.
- Chinstrap, Adelie, and Gentoo penguins all have the same flipper lengths



ANOVA Interaction Null Hypothesis

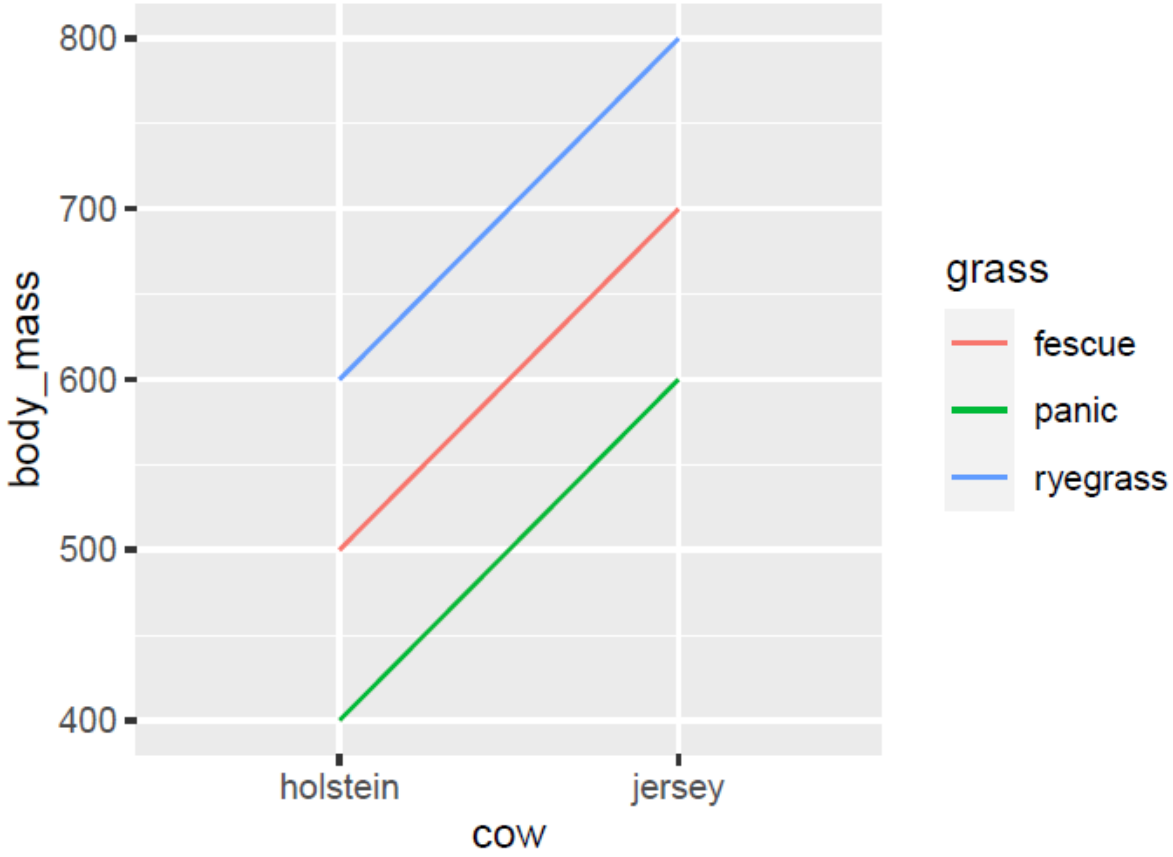
Interactions are harder to understand than main-effects.

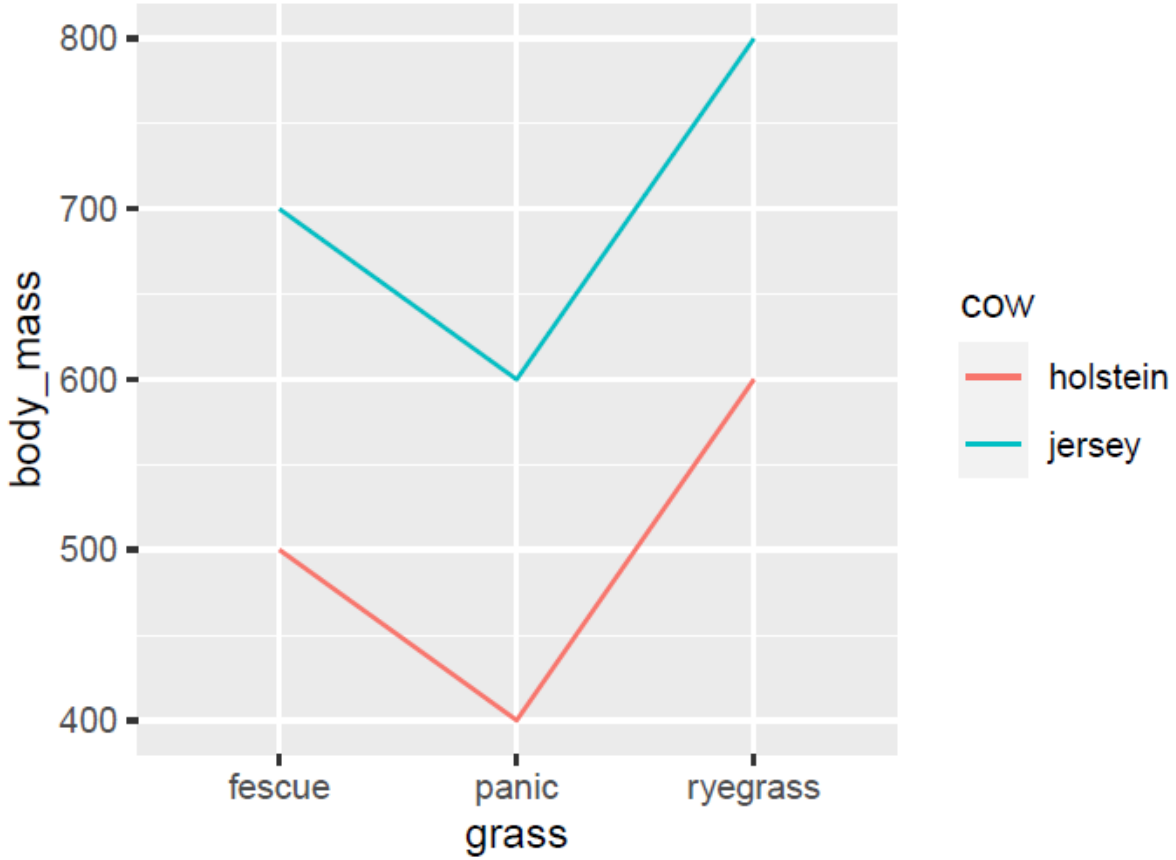
You can think of the null hypothesis for an interaction term as meaning that 'the ***differences*** in group means for factor 1 are the same when the data are grouped by factor 2' and vice versa. For example:

- Female penguins are always 100 grams lighter than males, regardless of species.
- Gentoo penguins are always 100 grams heavier than Adelie penguins.
- Holstein cows are always 200kg lighter than Jersey cows, no matter which forage they feed on.

It's easier to understand graphically:

ANOVA Interaction NULL – Interaction plots





ANOVA Interaction NULL in English

We could interpret the interaction null as:

- “Regardless of the type of cow, they are always heaviest when fed ryegrass, moderate when fed fescue, and lightest when fed panic grass.”
- “The difference in body masses among the different feed types are the same in both cow varieties.”
- “Jersey cows are heavier no matter which grass they are fed.”
- “The difference in mass between holstein and jersey cows is the same, no matter which grass they are fed.”

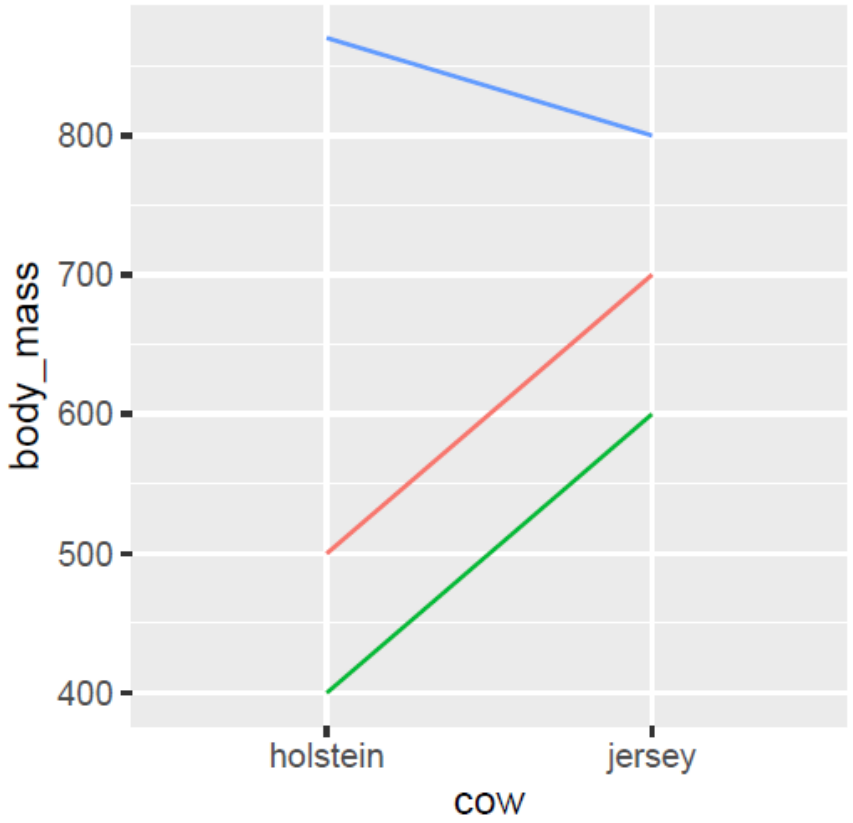
- Note that when there is no interaction, lines in interaction plots are always parallel.

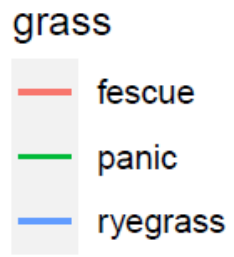
ANOVA Interaction Alternative Hypothesis

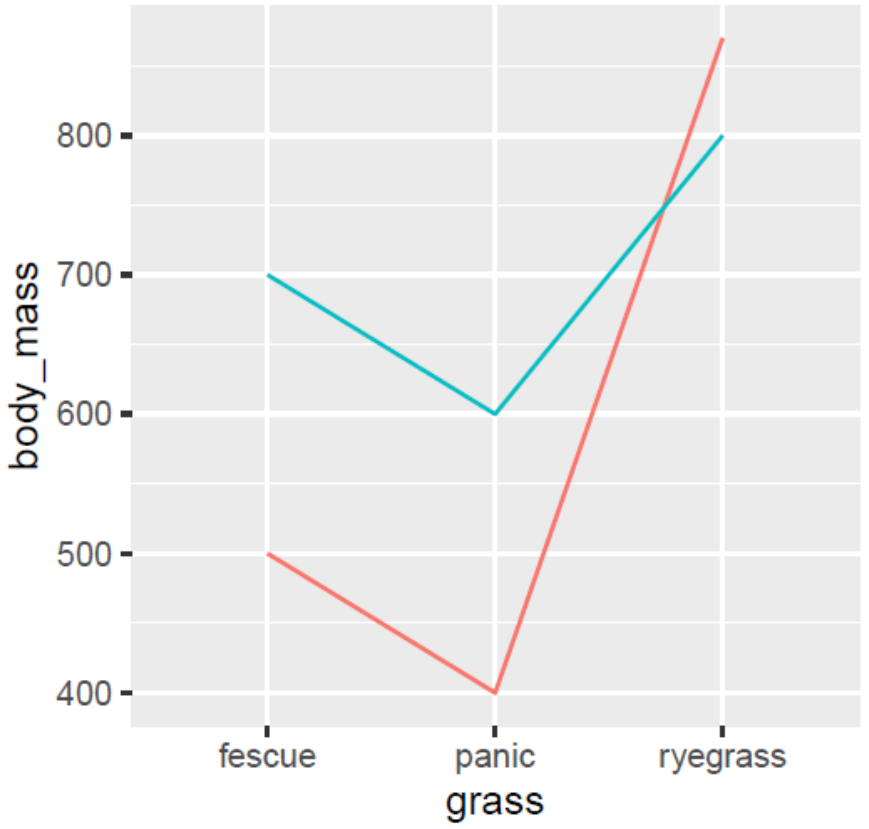
The alternative hypothesis is that:

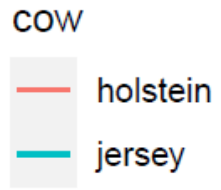
- The *differences* among group levels for factor 1 are not the same when data are grouped by factor 2. For example:
- Jersey cows are heavier than Holsteins when cows are fed panic grass, but Holsteins are heavier when they eat ryegrass.

ANOVA Interaction Alternative Hypothesis

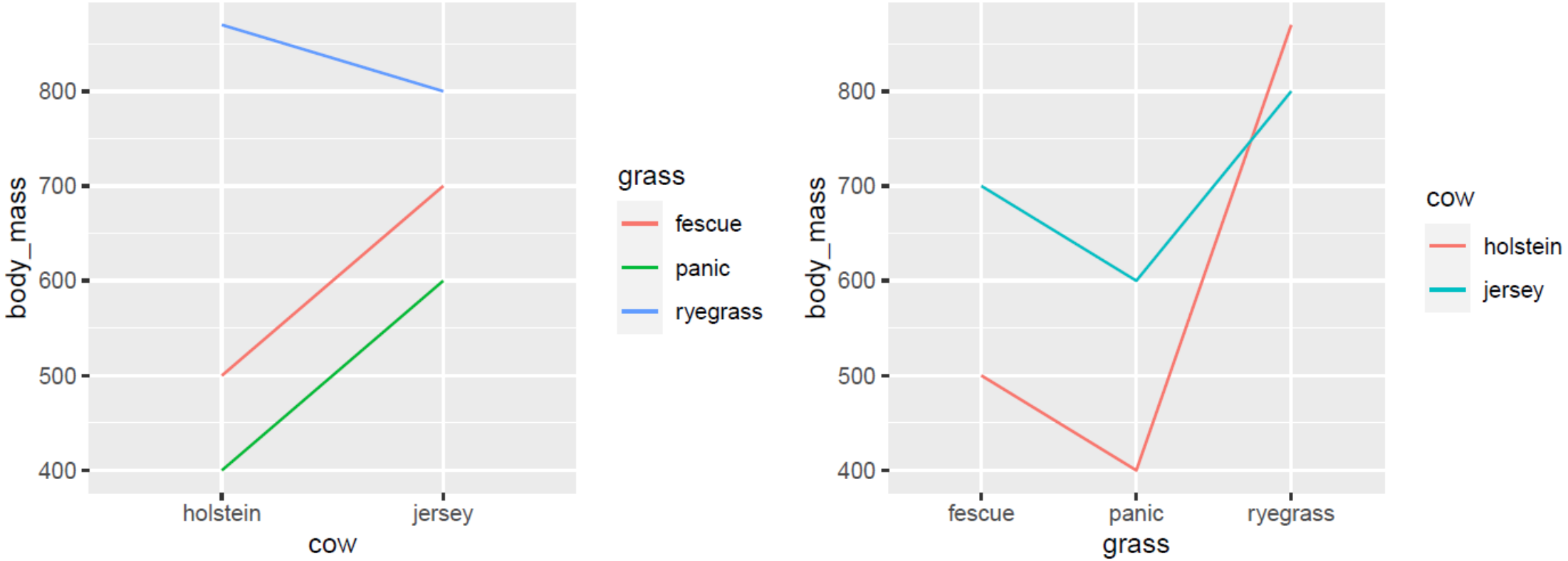








The jersey/holstein relationship has a *different* sign when the grass type is ryegrass.

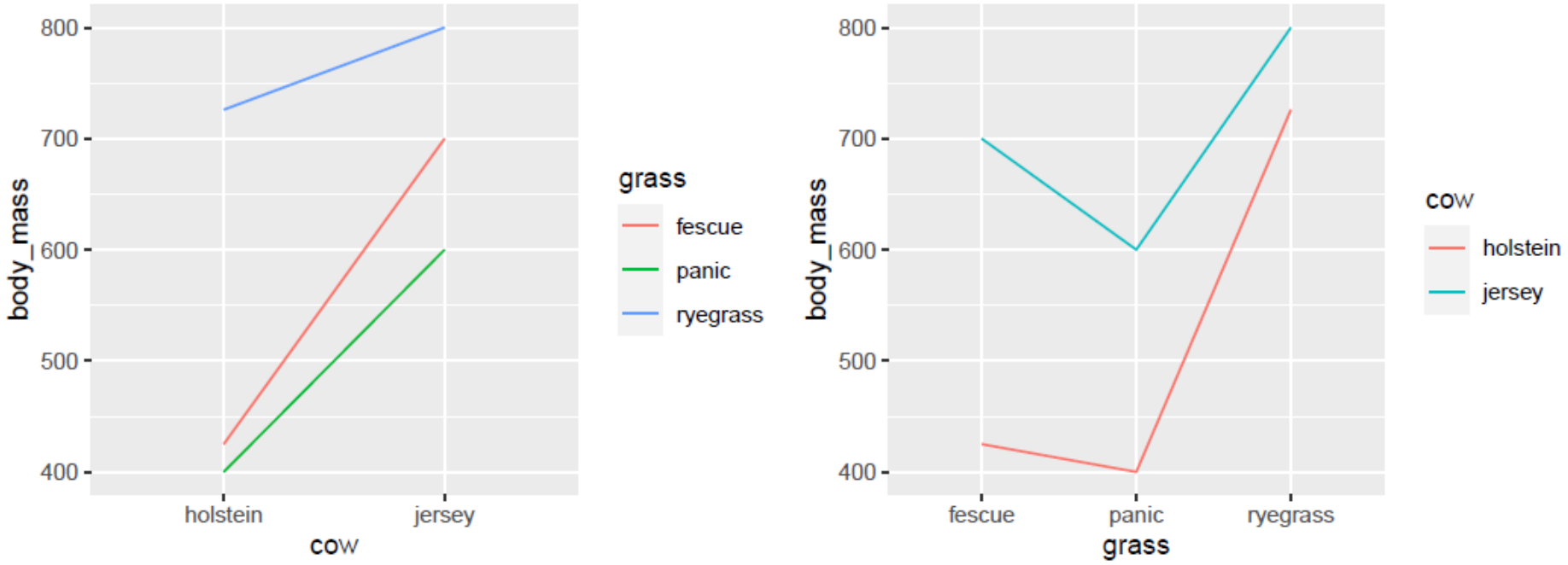


ANOVA Interaction Alternative in English

Some possible interpretations:

- “Jersey cows are heavier than holsteins when fed on fescue or panic grass, but holsteins are heavier than jersey cows when fed ryegrass.”
- “The differences in body mass between the three grass types depend on the cow breed.”

ANOVA Interaction Alternative Hypothesis



The jersey/holstein relationship has a *different* slope within each grass type.

Interaction Plots

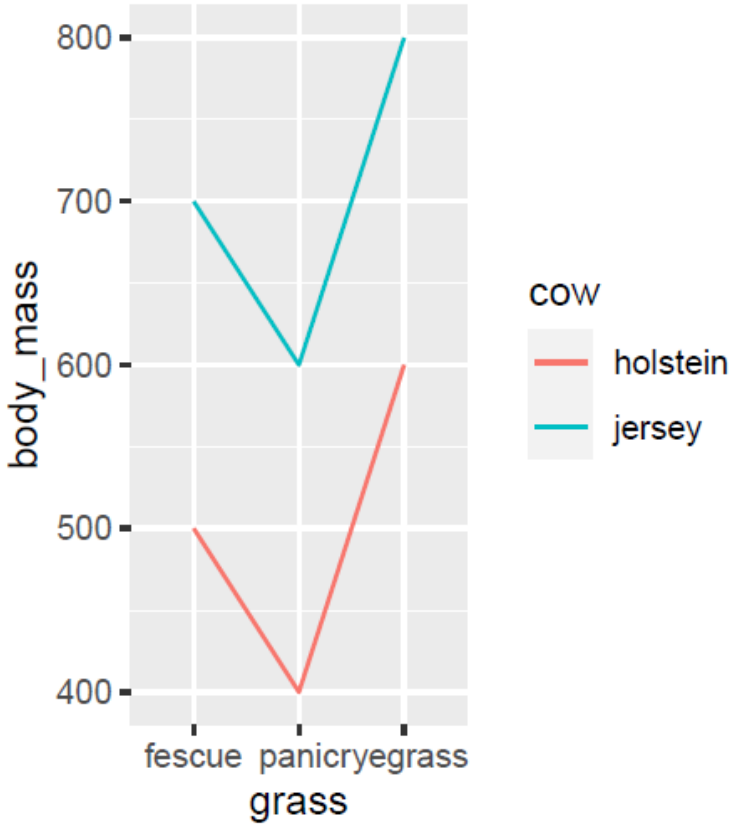
Interaction plots show the group means for data conditioned on 2 factors:

- Factor 1 is grouped by position on the x-axis
- Factor 2 is grouped by the color or texture of the lines/points

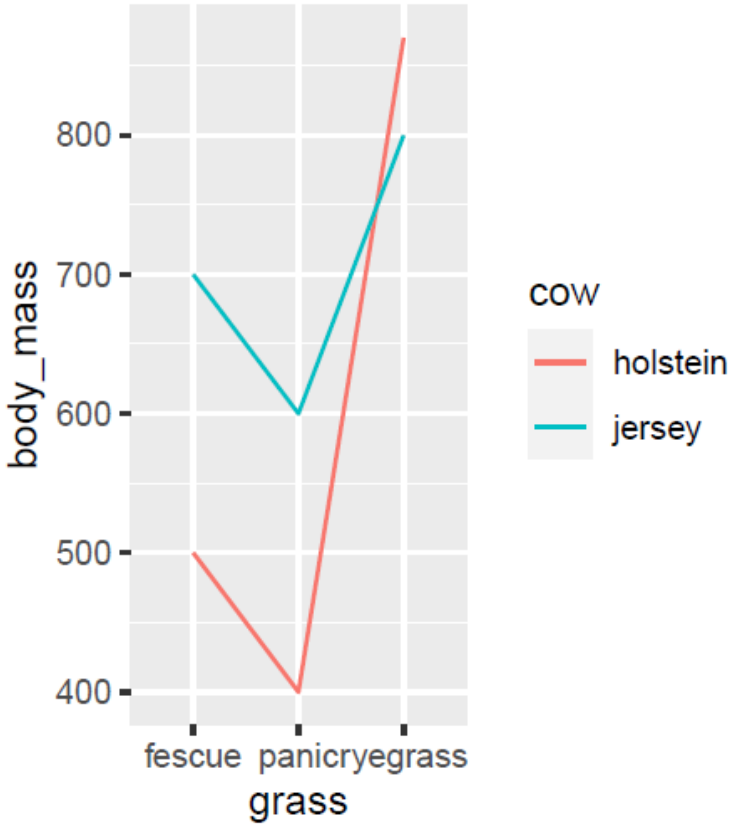
Interaction plots have *parallel lines* when there is no interaction!

- They are a very easy way to visualize interactions.
- Usually easier than expressing the interaction verbally.

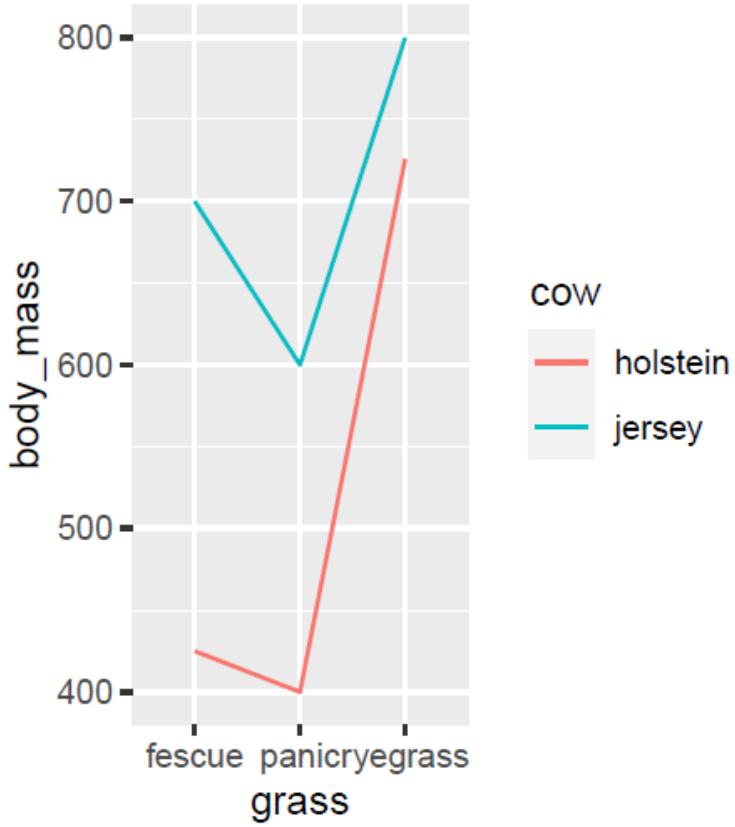
Interaction Plots: Comparing NULL with Alternative



NULL



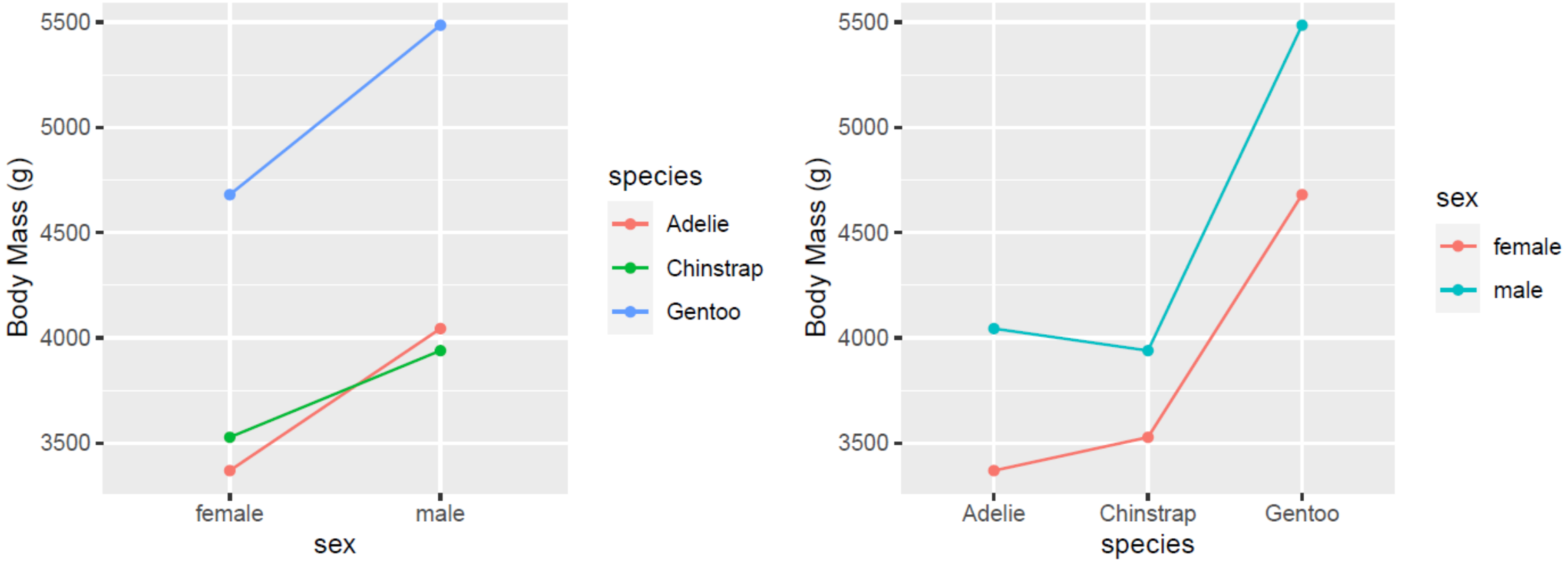
Alternative:
crossed lines



Alternative:
Lines not parallel

- Parallel lines: indicate no interaction.
- Non-parallel lines: slopes have different *magnitude*
- Crossing lines: slopes have different *sign*

Interaction Plots: Penguins



Is there a species/sex interaction?

ANOVA Factorial Design: Cell Sizes

For an ANOVA, does it matter which order you specify the model terms?

- Not if you have the same number of observations in each group!

Let's review our models from the salamander ANOVA assignment:

```
fit_add_1 = lm(SVL ~ Site + Sex, data = sals)
fit_add_2 = lm(SVL ~ Sex + Site, data = sals)
```

Unbalanced ANOVA: Fit 1

```
Analysis of Variance Table


Response: SVL
           Df Sum Sq Mean Sq F value    Pr(>F)
Site        3  738.7  246.22  12.559 1.048e-07 ***
Sex         2 4661.4 2330.68 118.879 < 2.2e-16 ***
Residuals 267 5234.7   19.61
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.'
0.1 ' ' 1
```

Unbalanced ANOVA: Fit 2

```
Analysis of Variance Table


Response: SVL
           Df Sum Sq Mean Sq  F value    Pr(>F)
Sex         2 5128.1 2564.07 130.7832 < 2.2e-16 ***
Site        3  271.9   90.63   4.6227  0.003594 **
Residuals 267 5234.7   19.61
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.'
0.1 ' ' 1
```

Unbalanced Anova: Cell Sizes

The R function `xtabls()` can produce a table with the number of counts in each group:

```
xtabs(~Site + Sex, data = sals)
     Sex
Site female male unknown
   A     10   17      30
   B     15   27      16
   C     26   28      50
   D     11   11      32
```

Some combinations of factors have more observations than others.