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Undergraduate Course: Biology 268-Mechanisms of Animal Behavior

Overview:

Our Data Expedition focused on introducing students to the application of circular data in regard to animal navigation. Students worked in groups of four to run a phototaxis experiment, collecting data on the orientation of pill bugs to a light source. Then, each group input their circular data into RShiny, an interactive R-based program specifically designed to output circular statistics. Students interpreted their results and decided whether they should reject or accept their hypothesis about the pillbugs behavior to light. Near the end of class, we accumulated data from all groups to examine how results changed in the RShiny program with a larger sample size.

This exercise was a capstone to a series of class sessions focused on orientation and navigation. The students read primary scientific literature discussing topics that often use circular statistics in their methods. The goal of this exercise was to give students a tangible understanding of when to use circular statistics and why they would want to use circular statistics over linear statistics for research questions related to navigation.

Guiding Questions:

- How do pillbugs orient in response to light?
- How would you design an experiment to test for phototactic behavior?
- How do circular and linear data differ, and when would you use circular statistics in research?

Homework:

The students were assigned a 1-page pre-reading on phototaxis and photokinesis to introduce them to the subject of the exercise. This homework introduced a case study of pillbugs' photokinetic reaction to light. The students were then asked to interpret photokinetic linear data in their own words, as well as brainstorm how they would change the experiment to test for phototaxis. Ideas were discussed at the beginning of class to start the exercise off.

Classroom Exercise:

This expedition allowed students to develop and test hypotheses relating to animal orientation. Our class lesson began with having the students explain photokinesis and phototaxis in their own words. After, we gave examples of organisms that display each light induced behavior. We also covered linear data analysis techniques. All of this information was centered around the assigned pre-reading. Students were then asked to discuss the results of the pre-class reading and to brainstorm ideas for testing phototaxis in their groups. Groups shared their ideas with the class for discussion. The concept of circular data and its analysis was then introduced, and the students were presented with the exercise set up: pillbugs, orientation arenas, boxes that would act as

separators to keep ambient light from entering the arena, and lamps. Overhead lights were turned off, and the window shades in the room were drawn as well to lessen light pollution. In their groups, the students were then asked to form hypotheses regarding the pillbugs' orientation (towards or away) in response to light cues. From there, the students performed their experiment, which proceeded as follows:

1. Students in groups of four were given six pillbugs in paper cups, an orientation arena inside a box, and one lamp.
2. The orientation arena was placed with the 0-degree end facing toward the projector. They placed one pillbug at a time in the center of the orientation arena under the small paper cup allowing the organism to dark adapt for 30 seconds before the trial began.
3. The lamp was fastened at the end of the table facing towards the opening of the box, which was 18 inches away. For the "experimental" group the students would turn the light on, and for the "control" group would leave it off.
4. Students then lifted the cup from the pillbug and recorded the compass direction it was moving when it reached the edge of the orientation arena.
5. Students then repeated these steps five more times, for a total of three "experimental" and three "control" trials.
6. One member of each group then wrote their results on the whiteboard.

Using the collective class data written on the whiteboard, we demonstrated how to use the RShiny app, and asked the students to recall what each of the calculated circular statistics meant and how it differs from linear statistics. The students then returned to their groups and analyzed their own data using the RShiny app while the instructors walked around providing assistance.

The students were then asked to discuss how their results compare to their hypotheses. Most of the class had hypothesized that the pillbugs would be negatively phototactic, meaning that they would turn from the light, since their usual habitat is dark, damp spaces such as under rocks. Statistically, we saw that the data showed a large spread of directions, with no statistically significant orientation direction for either the experimental or control groups, which was unexpected. Visually, the plots of our combined class data showed that some pillbugs did have a strong negative phototactic reaction to light, while others had no preference, making our data have a large spread. This contrast between the statistical outcome and the visual pattern provides enough preliminary evidence to justify continuing with the experiment, but with some adjustments. We discussed the factors that may have led to such a surprising result. Some of the answers we received were:

- Different developmental stages of the pillbugs
- Possible different species of pillbugs
- Ambient light from the projector
- Heat from the lamp
- Stress from transport or being handled

This showed that perhaps there were some unaccounted-for factors affecting the experiment. As an exit ticket we asked students to come up with ways to trouble-shoot these factors if they were to run the experiment again. Some ideas mentioned were dark adapting the pillbugs or 24 hours prior to the experiment, as well as ensuring the pillbugs collected are all from the same species. These ideas will be taken into consideration for the next iteration of this exercise. Lastly, the students were asked to send their plots and statistics from their individual groups to the instructors as well as explain their groups results in their own words and why they may have differed to the results from the rest of the class. Some students enjoyed this exercise so much that they kept their pillbugs and orientation arenas to run more trials in their own time!

Additional Information:

- Rshiny Program- https://rfitak.shinyapps.io/circbio/
- Curated dataset from this class - Pillbug_Data_2025

Plots and Stats for Whole Class Data (~36 students):