

Content Guideline for a Research Paper

Research papers are unique forms of writing, and constructing one with skill and clarity is key to our discipline. Here I provide advice for what to include in each section of your research report. As with all writing, you can find more ideas by reading published papers in your field (modified from resources on Anna Hargreaves' website).

Introduction:

- Start with the broad concept and narrow down to your specific research question(s).
- Tell the readers why the topic of your study is interesting or important, without overstating.
- review relevant literature: what is known already from theory (broadest), empirically in general (more specific), and empirically about your specific study system and/or question (most specific).
- Ideally, your research question will fill a gap in knowledge (e.g. we know A but we don't know B). Strive for this approach, so the introduction explains A and sets up expectations for B. That said, the size of the 'gap in knowledge' that you can fill in a class project will likely be small, and may simply be confirmatory within a system (e.g. we expect A in general, but we don't know if this occurs in our particular study system. An alternative might be B).
- Pose one or two clear questions (up to 3 if you can fit them in). You don't actually need to state it as a question, but you can. E.g. 'Here I asked, how does A change with B in study system Z?' We suggest placing this as the topic of the final paragraph of your introduction.
- Ideally, you will outline your expectations under a series of alternative hypotheses. This means that whatever you find, it will tell you something about the system. E.g. 'Under hypothesis X, we would expect A to increase with B. However, an alternative hypothesis is Y, in which case we would expect no change in A with B.' This can be challenging, but is something to strive for. Hypotheses do not need to have formal names, but if someone has previously outlined a particular hypothesis you should reference them. Ideally, one would spend the middle intro paragraphs giving the background to those hypotheses.
- If you cannot set up your expectations within alternative hypotheses, at least state expectations. E.g. 'Here I asked, how does A change with B in study system Z? Based on previous findings in which A increases with B (reviewed above), I expected A to increase with B.'

The whole intro should go from big picture to more focused on what you study both from paragraph to paragraph and within paragraphs. Make sure ideas lead easily from one to the other and that new topics don't jump out as surprises. Aim your introduction for 3-4 paragraphs.

Methods:

- Should describe clearly what you and the class did and why.
- Provide sufficient detail so that the methods could be repeated elsewhere and be interpreted fairly BUT avoid extraneous details (unnecessary or too specific). When in doubt on what to include, focus the methods on the details needed in order to understand your results.

- It is expected that you use the first person when describing what you/we did, either plural ('the class' or 'we') for the data collection methods, or singular (I) for the analysis.
- Consider using subsections in your methods e.g. titles like "Video data collection", and "Data analysis".
- Precise coordinates and extraneous details about every site can be given in the supplementary information or an appendix.
- Make the reason for your methods stand out from the details of how you did it. E.g. "In order to ask how A increased with B, I grouped the data by X and visually assessed blah blah blah"
- Data analysis includes what was done to the data between raw data and the values presented in the results. For example, if you calculated species richness as the number of species in each plot, this could be stated simply. If you calculated an abundance-weighted diversity metric such as Shannon's diversity, or a beta-diversity index or metric of similarity, explain these in the methods.
- If you used a function in R to estimate a metric, do not recite the function used, but rather explain what you did (i.e. what you told R to do) in general, mathematical, statistical, or ecological terms. You can refer to the R function and/or package in brackets.
- It is not typically necessary to describe how figures are made, this is implied by the figure itself and figure caption. E.g. If you plot the mean and standard error of Shannon's diversity for each site, this is almost entirely implied in the figure, as long as the caption states that the points \pm error bars are mean \pm SE within replicates at each site.

Results

- Provide a clear, logically organized narrative of the results
- Results should be factual statements about what was found. Be careful not to include methods or interpretation of results in this section. (those go in Methods and Results, respectively).
- A results section is typically composed of a written description of the results, with references to figures and/or tables.
- The writing can be short, but all figures or tables in the results need to be referred to within the written results section.
- A good results sentence describes the biological finding, and then refers to the figure, table, and/or a statistical result in brackets. E.g. 'Species richness increased with latitude (Fig. 1)'. This way, the visualization or analysis provides support for the findings that you report. Don't talk about a figure as a subject, e.g. not "Figure 1 shows us that..." or describe every nuance in a figure (we can see it).
- If there is a particular aspect of the data in a figure that you want to highlight in your discussion, do mention it in the results.
- use tables to provide extra details where readers would want to look up specific values, or to summarize information that is too cumbersome to write in the text.
- make figures (and tables) visually clean, appealing, compelling, and easy to understand
- In general you should support all statements that suggest a contrast or relationship with a statistical result. If the result was not significant, find languages that matches. If you see a trend but the model report is that it is not significant, the result is a relationship that doesn't differ statistically from zero (not "a trend that was marginally significant")

- Always report the effect size (mean and error estimate of an effect), not just the significance. If A changed with B, did it increase, or decrease with B, and by how much?
- Remember all of the things you have learned about sound inference. A positive regression slope between two variables represents a relationship, but nothing of causation. Find language that matches. “A increases as function of B”

Figures – embedded within Results

- Figures should be embedded in the Results (or in the intro if it is a conceptual figure) following the text that first refers to them.
- Figures need to answer the questions set out in your paper, and all of the information needed to understand the figure should be clear in the figure and figure caption.
- Figures should be formatted with clear axes with appropriate units
- Figure captions go **below the figure**
- Figure captions have a title, and are followed by sentences that include all of the information needed to interpret the figure. E.g. “Fig. 1. Alpha diversity in a disturbed and undisturbed habitat. Points represent mean values across replicates, and error bars represent standard error.”
- The entire caption should be on the same page as the figure, resize the figure so this is possible, caption can be single-spaced. Paragraph text should stop above the figure and continue after the caption – don’t have text going beside the figure.
- Figures plus captions are not normally surrounded by another box, but just float in the text (see any published paper for examples).

Discussion

- Start off with addressing the question(s) set out in the introduction, using the same language. Think of the discussion as the other side of a bridge from where the introduction left off. Use similar language as in the introduction to answer the question and address the hypotheses.
- It is sometimes helpful to signpost the discussion’s outline with a sentence in the first paragraph of the discussion. E.g. ‘Here I discuss these results in light of A, B, and C.’ where A, B, and C are the next 3 paragraphs. i.e. Literally just tell readers what you are going to tell them.
- If something was not what you expected, or surprising, expand on that. This is could be (e.g.) a good topic for paragraph 2.
- discuss caveats in the interpretation of results – at what scale can we expect these results to hold in systems other than this study? This usually makes a paragraph.
- Use references to compare findings to other published work and the broader literature.
- Discussion does not need to be long – keep the discussion to the topics addressed in the paper.
- Structure your discussion so that there is a clear focus of every paragraph, with a topic sentence.
- Avoid discussing topics that aren’t within the bounds of the paper, or talking about the myriad other things that one could do in the future. This will keep your discussion focused and useful.

- No need for a 'conclusion'. However, sometimes a conclusionary paragraph helps to close out the discussion.
- Aim your discussion for 4-5 paragraphs, always good to aim short and see what happens.