How to write a scientific paper for the USAP course book

Scientific papers are not written in the same style as a letter or an essay for English class. Scientific writing is technical and one of the objectives is to communicate much information in as little space as possible. Scientists sometimes pay several hundred dollars to publish papers, and this is largely dependent on the length of the manuscript. In addition, readers should not have to wade through "fluff" to find important information. Thus scientific writing is usually very concise, but this doesn't mean it has to be boring or difficult to read.

Most scientific papers follow a specific format made up of four main sections: introduction, methods, results and discussion. Accordingly, any scientist reading a paper knows to look for certain information in each section.

At the end of the course we will assemble most of the research papers, along with other materials, into a course book that will represent the OTS-USAP course. As with any publication, certain style and format guidelines must be followed for consistency.

Abstract: The abstract must include a brief description of the system and question studied, as well as a succinct summary of the results and conclusions. A good abstract will give the reader an idea of how your study fits into a broader context, and will provide all the information necessary to allow the reader to assess the importance and relevance of the paper to his/her own work. Many scientists may read just the abstract of a paper, so it is important to get your main points across in the abstract. Write the abstract last.

Introduction: The introduction starts with some background information about the study. This information provides the motivation for the question addressed. Why should we be interested in your study question? What is the basis for your hypothesis? What is the "big picture?" The introduction always makes the answers to those questions clear. In addition to the background information, the introduction should state the question(s) and/or hypotheses and predictions clearly. However, you want to avoid, if possible, using the words "hypothesis" and "predictions." The introduction outlines the focus of the paper and introduces the reader to what is presented in the discussion. Some paper-writing guides suggest writing the introduction fourth, but it can be started earlier and revised later.

Note that the focus of the introduction is rarely, for OTS purposes, about the study organism. The introduction should focus on ideas and theory. Information about the study organism is presented in the methods section.

Methods: The methods section often starts with a description of the study site and of the system/organism involved. The methods section is also where you describe your experimental design. Include enough detail that the reader can repeat your experiment if desired. Methods sections include a description of the statistical analyses performed and sometimes a justification for why these were appropriate tests. Raw data, results, and their interpretation do not belong in the methods section. Do not present any methods for which you will not present results, and vice versa.

This section is often written first.

Results: In this section you report the outcome of your experiments. The results section often begins with descriptive results and later becomes more specific. Report results of all statistical tests and state the direction of the outcome. Do not say "A and B are significantly different" but "A trees are taller than B trees." Do not use the word "insignificant."

Tables and figures (graphs) are used to summarize and present information effectively. The information in them should be referred to, but not repeated, in the body of the results section. Similarly, do not duplicate information in figures and tables. Lastly, only factual information about the outcome of the experiment should be reported. No interpretation or contextual information should be included. Do not draw conclusions about your hypotheses in this section. This section is generally written second.

Your results should be presented in the order in which you describe the methods and statistics in the Methods section.

Discussion: This section is devoted to the interpretation of your results. Avoid saying "my hypothesis was supported/rejected" and instead talk about the ecology of the results. What are the implications of your results with respect to the questions addressed? If your results do not support your hypothesis, can you refine the hypothesis? It is very important to provide some context for your results in this section. You *must* reference other research on the topic in question and relate your study to past work. Do your results fit in with the previous research or do they fly in the face of everything others have previously reported? Even if your results are not what you expected, there is usually some aspect that *is* interesting or surprising. Ultimately, you might be able to suggest avenues for future research, but your suggestions should follow logically from what you did and/or found out.

Discuss all results presented in the results section. You may discuss them one by one, but if so, you need to tie them all together in the end.

Keep in mind that your study didn't "fail" if you find you reject the alternate hypothesis. "Negative results" are also informative. Present the results of your study in a positive light whatever the outcome of the statistical analysis. However, you don't need to tie your paper to a conservation angle to make it relevant, or assert that it will change life as we know it.

In OTS projects it is common for sample size, or problems with methods, to affect how you interpret your results. In the discussion, you might want to include a VERY BRIEF paragraph that addresses this. If so, you need to indicate not only the nature of the problem, but also how your "problem" affects the data or their interpretation. This BRIEF paragraph should be included only if absolutely necessary, and comes at the end of the discussion, after you have considered your results in a positive light and interpreted them biologically. The paragraph is meant to be a *caveat*, and is meant to be informative. It is not meant to denigrate the study.

Finish the discussion with a positive summary paragraph. The discussion section is generally written third, and always after writing your results section.

Acknowledgements: A short section thanking the main people that helped in the logistical setup of the project and/or provided advice. Be generous but not sappy or frivolous – do not thank your dog 'fluffy' for moral support. Acknowledging any funding sources is essential.

Literature Cited: Many different bibliographic styles exist. So that we can be consistent stylistically, we use the bibliographic style of the leading ecology journal, Biotropica, as a template.

Citations in the body of the paper can include up to two authors and the year of publication (e.g. Benoit and Glass 1983). Multiple citations are separated by commas and are in chronological order (e.g. Adsit and Roth 1983, Bryant 2001, Hill et al. 2004). Citations of articles with more than two authors include only the first author's name followed by "et al." (e.g. Mangi et *al*. 2004). If an author has published multiple papers in a single year, then citations are distinguished by a lowercase letter in the text and bibliography (e.g. Parm 1988a, 1988b).

In the literature-cited section "et al." is replaced by the names of all authors. The first word of article titles and book titles should be capitalized. Journal names and proper nouns are also capitalized. Do not abbreviate journal names. Only scientific names (Latin) are italicized. Nothing is underlined, capitalized, or put into bold type. Whatever you cite in the text needs to appear in this section. Whatever appears in this section should be referred to in the text. **We do not accept web pages as references.** If you need to cite a chapter in an edited book, the proper way to do it is:

Huxley, C. R. 1991. Ants and plants: a diversity of interactions. In C. R. Huxley and D. F. Cutler (eds) Ant-Plant interactions. Oxfort University Press.

Unlike in many of the social sciences, you reference only works that you have read yourself. If a paper that you are reading cites a relevant study, you must look up that paper and read it.

Tables: Don't include "raw" data or output from JMP in your table. Table legends are placed as a heading *above* each table. Legends should provide enough information so that the table can be interpreted without reference to the text (see example). Include the species name and, if statistical tests are presented, state the test performed. If you present your statistical results in the text, they should not be repeated in the legend. Tables should be numbered consecutively, beginning with the first one referenced in the text. Tables should have no vertical lines. They have a heavy horizontal line at the top and bottom of the table, and a 'normal' horizontal line below the column heading. You can use the table autoformat option "simple 1" to format your table. Multiple tables and/or figures can be placed on a single page, but none should be split between pages.
Place tables at the end of the paper, after literature cited. All tables should come before all figures, regardless of the order in which you refer to them in the text.

Figures: Do not use figures created in JMP. The figure legend comes *below* each figure (see example) and, like the table heading, should provide enough information so that the figure can "stand alone." Graphs made in Excel should be free of horizontal lines and shading and should be in Black and White (no colors please). Use the "paste special" option in Word to copy just the figure, and not the entire Excel workbook, into the Word document.

Figures should be numbered consecutively in the order they are referenced in the text. The font size on the axes, axis labels, and legends (if included) should be identical to the font in the text. Be consistent with the formatting of your figures.

Please place figures at the end of the paper, after the table(s).

Important general information:

- **ALWAYS** *italicize* scientific names.
- Use 12-point Times New Roman font.
- Margin settings should be 1.25" on all sides and aligned left. All hard copy versions you hand in to us for grading should be 1.5 line spaced.
- Arrange the paper in the following manner: Title, category, participants (your name first, others alphabetical), site, keywords (alphabetized), introduction, methods, results, discussion, literature cited, tables, figures (see the sample paper).
- Paragraphs should be indented; no line spaces are included between paragraphs.
- Begin sentences with letters, not numerals. In the text, spell out numbers from 1-9. For numbers ≥ 10 use numerals. Do not begin sentences with abbreviations. Use a zero (0) before the decimal point for $-1 <$ numbers < 1.
- Italicize P for P-values and the symbols for statistical tests (e.g., t, F, X^2) or other symbols.
- Use a space before and after equal signs. Use two spaces after the period at the ends of sentences.

In general, do not write your paper with your professors or classmates in mind. Instead, your audience should be someone who would pick up a scientific journal and read the article with little or no knowledge about the organism you studied, or the question you addressed.

For the first draft, we need a hard copy of the paper.

When you turn in the final version of your paper, we need a new hard copy, the first draft, and an electronic copy. The electronic version must be in Word, and must include all figures and tables as part of the Word document. *Again, please* paste tables & figures as 'pictures' using the 'paste special' command option in the Edit menu of Word. And remember that there should be no bold, and no colors, anywhere in the paper. An exception might be made if it is necessary to include photos, but check with us first.