

GUIDELINES FOR WRITING AND PUBLISHING SCIENTIFIC PAPERS

GUY A. BALDASSARRE, SUNY COLLEGE OF ENVIRONMENTAL SCIENCE AND FORESTRY, SYRACUSE, NY, 13210. gabaldas@esf.edu

As professionals engaged in some aspect of wildlife science, a significant amount of your time will be spent communicating with other professionals through writing. Most professionals are confronted with a staggering array of written information, thus it is critical that those writing such material do so in a clear, concise, and accurate manner. The following guidelines are an introduction to the process of scientific writing.

A scientific paper has been defined as "a written and published report describing original research results." The watchwords of scientific writing are clarity, brevity, and organization, which are essential because scientists usually read scientific literature for information and not entertainment. Thus, your task as an author is to convey information quickly, yet clearly, understandably, and concisely. To write a scientific paper, you generally will use the format and style described below, although there are many exceptions depending on where your material will be printed and to whom your audience is. However, although formats and styles vary from time to time and place to place, the clear, concise, and organized style does not. Remember, never let anyone tell you scientific writing is dull and dry. An accurate, terse, and lucid presentation of the information at hand is a work of beauty and excitement in its ability to convey maximum information in minimum space and reader time.

THE TITLE

In preparing the title, remember one thing: thousands of people will read the title, and from among those people will emerge those who actually *read* the paper. Thus, a poor title is among the surest ways to assure your paper will not be read, whereas a good, informative title is the way to encourage readership. You should consider the following when developing the title:

- (1) be brief (usually <10 words), but be specific and informative.
- (2) where appropriate, include the nature of the study, principal species involved, and geographic location.
- (3) do not use "cute," poetic, or idiomatic titles.

For example, if your study described bird species diversity in Meadow Brook Marsh, a forested wetland in Adirondack Region of New York, and the title of your paper was "Bird Species Diversity," many of the pertinent details would be missing whereby a reader might not be inclined to look further into the paper. Accordingly, a better title would be "Bird Species Diversity in a Forested Wetland in the Adirondacks, New York."

THE BY-LINE

- (1) the by-line identifies the author and institution where the investigation was conducted and also serves to provide an address for the reader who wishes to contact the author for a reprint of the article.

For example, when I publish a paper based on work done at ESF, my by-line reads as follows: Guy A. Baldassarre, Faculty of Environmental and Forest Biology, State University of New York, College of Environmental Science and Forestry, Syracuse, NY 13210. Many journals now include an email address either directly in the by-line or as a footnote to the conventional address.

THE INTRODUCTION

The Introduction is a critical part of a manuscript because it is here that you *introduce* your paper by stating the reason for the paper's existence. If the problem (i.e., scope) of the paper is not stated clearly and understandable, the reader will have little interest in your solution and often reads no further. The suggested "rules" of a good introduction are as follows:

- (1) review the pertinent literature so as to orient the reader.
- (2) clearly present the nature and scope of the problem to be investigated. This statement justifies the paper, often by highlighting an unanswered question or contradicting a hypothesis. This justification often involves referencing the work of others and ultimately serves to "set the hook," so to speak, for the reader.
- (3) state your objective(s) or purpose of the paper briefly but clearly so the reader now knows *exactly* the purpose of the paper.
- (4) many manuscripts are rejected, in large part, because the Introduction did not convince the referee that the study was worthwhile

Introductions often are not long and indeed may be the shortest part of the paper proper. The important point is to develop a quality introduction as a means of orienting the reader to proceed further into the paper. The example below is the introduction from a paper I published in the *Wilson Bulletin* with one of my graduate students. The paper's title is "Activity Budgets of Mallards and American Wigeon Wintering in East-Central Alabama." *Wilson Bulletin* 99:457-464.

Recent studies in North America have used activity budget techniques to investigate nonbreeding waterfowl ecology (Paulus 1984, Quinlan and Baldassarre 1984). Most investigations, however, spanned only one winter period and focused on one species. A multiple species approach can provide new ecological and behavioral insights (McKinney 1973) relative to nonbreeding waterfowl ecology, and studies longer than one year are necessary to determine the influence of annual effects on various aspects of wintering waterfowl behavior. (**ORIENTS THE READER**).

We studied activity budgets of Mallards (*Anas platyrhynchos*) and American wigeon (*A. americana*) because these species are among the most abundant North American waterfowl (Bellrose 1980), yet little is known regarding their wintering ecology. Indeed, Fredrickson and Drobney (1979) noted the lack of data on nonbreeding waterfowl in general, and stressed the need to determine how species allocate time during this portion of the annual cycle. (**SETS THE HOOK**) This lack of information is significant because events during winter may affect survival and subsequent reproductive performance of these and other waterfowl (Krapu 1981, Heitmeyer and Fredrickson 1981). Jorde et al. (1983, 1984) studied wintering Mallards using, in part, activity budget techniques. Their study site (Nebraska), however, was north of most major wintering areas (Bellrose 1980), and thus may not reflect winter activity of most North American Mallards. Wintering American Wigeon also have received little study except for work by Soutiere et al. (1972) and Wishart (1983a,b), which concentrated on pairing chronology and courtship behavior. Here we determine (1) the activity budgets of Mallards and American Wigeon wintering in Alabama, and (2) the influence of habitat selection and weather on activity. (**STATES OBJECTIVES**)

DESCRIPTION OF THE STUDY AREA

This section of the paper may not always be needed. For example, the study may have been conducted in a laboratory. However, for field-oriented research, the description of the study area is an important part of the paper.

Generally, this section includes a basic description of your study area as related to the context of the paper. The latter point is important, as writers often include extraneous material that does indeed describe the study area but does not relate to the paper. Items to consider in writing this section are geographical location, climate, geology, soils, historical background, general vegetation cover, and dominant fauna.

MATERIALS AND METHODS

The main purpose of this section in a scientific paper is to provide enough detail that another competent professional can repeat your study. This section often goes unread because the reader has a basic idea of the methods involved in the study; however, enough detail must be in this section whereby your results would be repeatable, which is an important part of the scientific method. Some considerations for this section are

- (1) if possible, refer the reader to a reference of a particular technique rather than provide a step-by-step description of the whole process. This approach saves space in the paper, and otherwise would be unnecessary repetition.
- (2) always include the dates of each sampling period. For example, do not just write "water chemistry was sampled with a portable water analysis kit." Rather, "We sampled water chemistry each day at 1000 from 1-30 June 1997 at 3 randomly located stations in the wetland."
- (3) if your methods are lengthy, use subheadings to organize. For example, if you conducted a study involving a variety of components, subheadings might be Soil and Water Analysis, Vegetation Analysis, Bird Census, etc. These sections can then be matched in the Results section, which further compartmentalizes your paper and makes it easier to follow.

RESULTS

The watchwords for this section of the paper are to be accurate and concise. This section often summarizes information contained in tables and figures presented elsewhere in the paper. The important point here is to emphasize the main points of the data and never to repeat in the text the information contained in tables and figures. The basic rule: report the *major* versus "statistically significant" findings, recognizing that the significant findings are those you intend to revisit in the Discussion. Let the tables and figures handle the data details.

- (1) Good writing of Results sections reports summary data, not just summary statistics. Contrast the two sentences below:
 - (a) Body mass of adult male elk was heavier than adult females ($P = 0.03$; Table 1).
 - (b) Body mass of adult male elk averaged 45 kg more than adult females ($P = 0.03$; Table 1).

The latter sentence provides information that orients the reader as to what the major finding was, whereas the former sentence requires the reader to leave the text and go to Table 1 to find the pertinent data.

- (2) Avoid statements like "Table 1 shows the results of the water chemistry data . . ." Rather, highlight a finding and then reference the table: Oxygen content was the only water chemistry parameter that varied during the study (Table 1).
- (3) When possible, cite statistical tests, tables, and figures at the ends of sentences. This placement avoids breaks in reading the text.
- (4) Subheadings are helpful in Results as a means of organizing the presentation of data and making it easier for readers to come back into a paper and find information.
- (5) Be *meticulously consistent* in reporting Results. The idea of consistency is to facilitate reading of the paper so that the reader never has to second guess items that reappear in the text.

For instance, if your study area was on the Trinity River, do not mix-mode Trinity River, Trinity Drainage, and Trinity. If you are reporting a common name for a species (e.g., western pond turtle,) use that name consistently: do not mix-mode western pond turtle, pond turtle, and turtle. If you prefer, after the first time you mention "western pond turtle" you can follow with (hereafter, turtle), and then use turtle throughout the paper. Remember, basic style is to report common name followed by the scientific name when you first mention the species; thereafter, use common name and *check* to see that you meticulously follow this procedure.

Do not report body mass ranged from 45-100 kg for males and 35.6 to 95.7 kg for females (either you are reporting body mass to 1 place past the decimal *consistently* or you are not. Similarly, when reporting results of statistical tests, be consistent: not $F = 12.456$ and then $F = 13.1$; not $P = 0.657$ and then $P = 0.34$. Do not mix-mode names of places.

- (6) When you submit a manuscript for publication, each table and figure should be on a separate piece of paper, not incorporated into the text, and placed at the end of the manuscript. Generally, use a figure to depict a trend and a table to present exact numbers. A note here regarding tables and figures: each should have a clear title and enough other information (labels, legends, etc.) so as to be clearly interpretable by the reader without any reference to the text. Number tables and figures separately but consecutively (e.g., Figure 1, 2, 3; Tables 1, 2, 3). Title tables at the top and figures at the bottom, and do not forget to include a scale and north arrow on figures. Never present the same data in both a table and a figure. Use metric measurements.

I've provided an example from the Results section of the Wilson Bulletin paper:

Mallard Activity Patterns (subheading)

Resting was the most frequent activity of Mallards (39-54%) during all months except February 1984 ($P < 0.05$; Fig. 1) and was usually the prevalent activity during each time block in the day. Mallard feeding increased throughout winter and was lowest during November (7-10%), and highest in January and February, except for single birds in February 1985 (Fig. 1). Feeding was higher in December and February of 1983-84 vs. 1984-85 ($P < 0.05$)

DISCUSSION

The Discussion is where you interpret your results, which often makes this section the most difficult part of the paper to write. Indeed, many papers submitted for publication are rejected not for lack of quality data, but because of a poor Discussion section. A most important principle here is to make the paper come "full circle" by discussing the data in the context of the justification and objectives stated in the Introduction. If the Discussion does not relate to these important points, the paper loses its ability to convince and to summarize within a specified context. To do otherwise is to produce a rambling paper that is cumbersome to follow, hard to interpret, and invariably rejected for publication.

Generally, the Discussion answers the following questions: what did the results mean and why did they come out as they did. In answering these questions, you usually will be comparing your work to the findings of others. The following points are among those that should be considered in writing this section:

- (1) Look to present the principles, relationships, and generalizations as evidenced in the Results. Remember, too, the point of the Discussion is to discuss the results, not to repeat what was already presented in the Results section.
- (2) Emphasize exceptions and contradictions to other work as well as agreements with work of others.
- (3) State your conclusions as clearly as possible and based on the data in the paper. Many Discussion sections suffer badly from reporting what an author "knows" about the topic versus what the data actually support.

- (4) Speculation should be clearly stated as such and limited but not omitted, and suggestions put forth for future or additional research.

LITERATURE CITED

This section correctly gives credit to the work of others by referencing material you actually mentioned in the text of the paper. In the Literature Cited section, list citations in alphabetical order using the author's last name. In text, reference the study the first time you refer to the work of someone else, and thereafter whenever it becomes obvious that you are no longer referring to that reference.

In text, for work authored by one or two people use the last names followed by the date the work was published (e.g., Smith 1987, Smith and Jones 1988). For work involving more than two authors, the correct citation format is to use the last name of the first author, followed by "et al.", and the date of publication. For a string of several citations, list them chronologically (from first to most recently published), not alphabetically by author.

The Literature Citation section is usually where an author is most apt to be careless. Again, be *meticulous*. The only way to assure mistakes do not creep into the Literature Cited section is to ultimately check all your citations against original hard copies. I *guarantee* you will find errors!

GENERAL WRITING STYLE FOR SCIENTIFIC PAPERS

VOICE

There are two "voices" in English: passive and active. Basically, if the subject of a sentence performs the action, the sentence is in active voice. The sentence is in passive voice if the subject of the sentence receives the action. The active voice is usually preferred because it is both more direct and less wordy. Consider the examples below:

- (a) The dog was called by Mary. (Passive).
 (b) Mary called the dog. (Active). Note reduction in words by 33%.

Hence, rather than write "The activity patterns of Robins were examined at Cranberry Lake", write "I determined the activity patterns of Robins at Cranberry Lake."

General Style: Use active voice.

PERSON

Use first-person pronouns (I, we) to denote agents of action, which avoids wordiness and confusion. Write "I found A was greater than B" versus "It was found that A was greater than B."

General Style: Use first person.

TENSE

Scientific writing uses two major tenses: present and past. Here are the general rules:

- (1) Established information: present tense.
- (2) Methods and Results sections: past tense.
- (3) Presentation of data: present tense.
- (4) Attribution of information (e.g., someone else's work):
past tense.

OTHER GENERAL POINTS

- (1) Avoid short, choppy word sequences because they are nearly always a sign of wordiness (e.g., "The ducks used to be," "The data are significant because," "There may have been," etc.). These phrases can almost always be replaced, and clarity not lost. Also, learn to spot wordiness by homing in on these short, choppy sequences (often around the verb "to be"). The "cure" is usually simple and obvious, once the problem is diagnosed. Here are a few examples:

Replace "a number of" with "many."

Replace "based on the fact that" with "because."

Replace "first of all" with "first."

Replace "for the purpose of" with "for."

Replace "in order to" with "to." In general, omit the phrase "in order to."

Replace "due to the fact that" with "due to" or "because."

Replace "during the time that" with "while."

Replace "in the month of May" with "in May."

Replace "it is interesting to note that" with the first word after "that."

- (2) Avoid using nouns as adjectives. For example, rather than "Summer Mallard activity budgets," use "Mallard activity budgets in summer."
- (3) Rework your paper several times. Eliminate unnecessary words and repetition, look for good organization and flow. Check paragraph structure remembering there are 4 main points to a well-constructed paragraph: (1) each paragraph begins with a solid topic sentence that quickly and clearly introduces the reader to the topic of that paragraph, (2) each sentence in the paragraph relates to that topic, (3) there is good transition between sentences, and (4) there is good transition between paragraphs. Proof read the final copy for typographical errors and misspellings. Also, have a colleague read and critique your paper before submission.

Spell check and **proof read** your final version, even if you have only made a few corrections. The goal of reworking your paper: perfection!

OTHER WRITING RULES-OF-THUMB

- (1) In a series, always use A, B, and C; not A, B and C.
The comma in this construction is never wrong and always used in good scientific writing.
- (2) Generally, avoid using a comma to join a compound predicate.
Wrong: The birds were captured, and then banded.
Correct: The birds were captured and then banded.
- (3) Do use a comma to join two independent clauses.
Wrong: We collected birds but we released mammals.
Correct: We collected birds, but we released mammals.
- (4) Use a comma to set off introductory phrases. The comma here is never wrong and avoids ambiguity, although some journals edit away from this comma. Consider the following sentences with and without this introductory comma: At night birds roosted in cavities versus At night, birds roosted in cavities.
- (5) Avoid constructing sentences with "respectively," which forces the reader to match items with those that appear earlier in the sentence. Example: The mass of males and females was 45 and 30 kg, respectively. Better: Mass was 45 kg for males and 300 kg for females.
- (6) Do not use the construction "and/or." The slash is used to denote the mathematical operation of division or to represent concentration (as in per). Example: The birds we captured were migrating and/or molting. Better: The birds we captured were migrating, molting, or both.
- (7) Do not use a colon to separate a verb or preposition from the associated object. Wrong: Our objectives were: (1) to measure the variable A, and (2) to test response B.
Correct: Our objectives were to measure variable A, and (2) to test response B.
- (8) Proper use of "that" and "which." Use that to introduce restrictive clauses (i.e., clauses that are essential to the meaning of the sentence), and use which to introduce nonrestrictive clauses, which are clauses not essential to the sentence.
- (9) Put modifiers in their place! Adjectives modify nouns and adverbs modify verbs, predicates go with subjects, etc. Put such pairs near each other. Example: The ducks at the far end of the lake were captured. Better: We captured the ducks at the far end of the lake. Note how the subject and predicate are now joined, in this case by switching to first person.

- (10) Do not misuse the demonstrative pronouns "this" and "these." Writers often begin sentences with either word used as a noun, which is confusing because all pronouns need antecedents (the noun they replace), and it is difficult to have a clear antecedent at the beginning of a sentence! Example: This means the data are inconclusive. Better: This analysis means the data are inconclusive. When "this and that" are used to point to nouns, they become demonstrative adjectives and clarity of meaning is never a problem. In general, whenever you use a pronoun, be sure the antecedent is crystal clear. Consider the following: We suggest cessation of feeding in January initiates an increase in digestive efficiency of pheasants, but this is not sufficient to maintain fat reserves. ("This" can refer to either supplemental feeding or digestive efficiency).
- (11) Recognize and eliminate dangling participles. First, recognize that a dangling participle occurs when the participle form of a verb (the -ing or -ed form) has no agent (subject) to perform the action attributed to the verb. Consider the following example: Ferrets were located at night using spotlights operated from trucks. Another one of my favorites: Rabbits were spotted using a 100-W spotlight from the top of a 4WD vehicle.
- (12) When rewriting, you often can eliminate the preposition "the" from a sentence, and there are LOTS of them in a paper.
- (13) Similarly, you can often eliminate the word "that."
Example: The data suggest that the lake was polluted.
Better: The data suggest the lake was polluted.
- (14) Always check subject-verb agreement. Plural or compound subjects take plural verbs, and singular subjects take singular verbs. Further, always remember that data are plural.
- (15) Common prefixes like post, non, pre, multi, inter, intra, mid, anti, bi, etc., are almost never hyphenated.
- (16) An adverb ending in "ly" plus a participle or adjective is always open, never hyphenated.
Wrong: poorly-attired man. Correct: Poorly attired man.
- (17) Hyphenate a verb-adverb before a noun but not after.
Example: The well-attended function was enjoyed by all.
The function was well attended.
- (18) Hyphenate confusing compound adjectives. For example, consider the phrases "new car owner," "new-car owner," and "new car-owner."
- (19) Do not worry much about split infinitives, which are verbs divided by adverbs, unless the modifier is far away from the verb. For example, The dogs were running wildly versus The dogs were wildly running. Even in the case of infinitives like "to sample" or "to decide," split infinitives are sometimes acceptable. Consider: To sample randomly versus to randomly sample. Generally, the "to" form of an infinitive is more likely to remain unsplit, but where would the Enterprise be without "to boldly go."

WORD CHOICE

Affect-Effect: Affect is a verb that means to influence, whereas effect is usually a noun meaning result.

Among-Between: Use among when a relation is between more than two items, and use between when the comparison is between only two items.

Circadian: About 24 hours.

Compare-Contrast: Compare points out likenesses, whereas contrast points out differences.

Compose-comprise: Compose means to make up, whereas comprise means to include.

e.g.-i.e.: the former means for example, whereas the latter means that is.

Ensure-insure: Ensure means to make certain, whereas insure means to assure against loss.

Farther-Further: Further indicates "greater in degree," whereas farther indicates more distance. Example: We walked two miles farther to discuss things further.

If-Whether: If is used to express conditions, whereas whether is used to express doubt. If it rains, the game is postponed. I wonder whether it will rain.

Impact: Impact primarily means the striking of things against each other and secondarily means effect. Hence, use effect as in "The effect of the experiment was . . ." not "The impact of the experiment was . . ."

In-Into: In means motion within a narrowly defined space, whereas into usually comes after a verb and means motion into space. Example: We walked into the room.

Irregardless: This word should never be used. Use regardless.

Live trap--Live trap: The former is a noun and the latter is the verb.

Percent--Percentage: Percent is an adjective (usually) or a noun, whereas percentage is a noun meaning part of a whole expressed in hundredths. Hence, percent error, not percentage error.

Precision-Accuracy: Precision denotes refinement (e.g., 3.45 is more precise than 3.4), whereas accuracy denotes correctness.

Principle--Principal: Principal means a sum of money or a chief person, and as an adjective denotes main or chief. Principle is always a noun and means a truth, a rule.

Since--Because: Since means from some time in the past, whereas because means "the reason that." Since 1980, the goose population has increased because of abundant food.

Then--Than: Than is a conjunction used for comparison, whereas then is an adverb denoting time.

To--too: To is a preposition (to the lake), whereas too is an adverb meaning also.

Utilization: Substitute the word use.

Very: Very, surely, extremely, and similar words have been overused as modifiers to the point of losing some of their value. Use these words carefully.

While: Means "during the time that." Use for time relations but not as a synonym for whereas, although, and similarly, all of which do not imply time.